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The Institution and the Network

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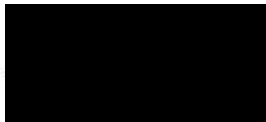
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For the true stars

Seren, Brenna and Tristan

To Stephen

my constant, if restless, Irishman. For sharing all this time with me

and to my beautiful writing and walking buddy

Rigby

Abstract

This research explores how National Research Centres in Higher Education systems can offer dynamic views of ways network-like organisations emerge and self-organise in institutional environments. My thesis considers the interplay between institutional and more network-like forms of organising by exploring the Australian Research Council's (ARC) Centres of Excellence (CoE) Programme as a complex system of science.

I provide a foundational review of the changing relationship between Higher Education Institutions (HEIs) and Research Centres to highlight the perception that today's science endeavours form part of a larger global research ecosystem. The thesis applies these perspectives to propose that CoEs can be conceptually viewed as a 'Janus object' in this complex space - that is, that CoEs occupy and can take views across both institutional and network-like environments.

The research integrates three studies to provide this more detailed 'view from the CoE.' The first study mobilises two bodies of literature to provide a foundation for the research approach. The first, from neo-institutional theory, considers how the CoE, as an informal organisation, might relate to the HEI through a form of 'collective rationality.' The second, from the field of network science, explores how network-like organisations can emerge with different properties of robustness and information exchange. I also respond to calls from empirical studies of research systems to consider how the 'self-organisation' of science might offer wider value to inform an understanding of complex systems of organising.

The second study explored how research professionals engaged in Research Centres interact within the HEI environment. This informed the third study which details a qualitative, exploratory study of the Australian CoE Programme. Contributions from 22 Research and Professional Leads, which covered three cohorts of the Programme funded in 2011, 2014 and 2017 also represented an overview of 'life spans' of the CoE.

CoE participants identified characteristics of emergence consistent with organisation in complex systems. Firstly, shared narratives from a high proportion of participants note a paradoxical environment of 'odd encounters', rather than formal interactions, with the HEI. Narratives also revealed highly effective forms of co-leadership roles between Research and Professional Leads which align closely with descriptions of 'authority' in network science. This suggests effective CoE leadership is via people acting as shared information exchange hubs.

The contributions also allow a view of the CoEs through their lifespan in relation to the HEI. From these I develop a set of 'network narratives' which demonstrate the pluriform nature of CoEs as an example of emergence. The narratives also reveal CoEs have potential to become highly autonomous, but return value as an important intermediary between the 'highly localised' institutional research environment and the global research system.

A strong volunteered narrative on gender and diversity policy also demonstrates an unexpected case of network-like 'percolation.' This paradoxical finding suggests policy formed within the CoE may be adopted by the institution which may in turn allow the institution to co-evolve. This suggests a potential for true, if less tangible, ecosystem effects as a result of the CoE Programme.

In integrating findings across the three studies I contribute to theory by proposing a new open architecture for institutional theory in response to long standing work by Scott (2004; 2008). This aims to realign network considerations inherent within neo-institutional theory with more recent phenomenological findings in network science. In illustrating examples through network narratives, I also extend the work by Watts (2004) to close the gap in the vocabulary between network science and institutional theory in ways that can support studies which explore institutional perspectives of network-like forms in complex systems.

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Chapter 1 An Introduction to The Institution and the Network

A year in the life of an institution

"… It's been a hard year, the day in and day out attacks on us, that hurts us. But this has happened in history. During the civil rights movement, in Vietnam, a lot of people attacked news organisations like the New York Times. Called them bad, evil, outside agitators. All I can say is, those guys are gone and the New York Times is still here"

Dean Barque, Editor of the New York Times (Garbus, 2018, The Fourth Estate)

> The Fourth Estate follows the tumultuous year at the New York Times in the aftermath of the 2016 US Presidential election. Diane Garbus' documentary takes us up close to this reactive period as journalists and editorial teams, working across two main sites in New York and Washington, wrestle with the social media storm which engulfs the traditional news cycle. A year into my PhD studies, rather than viewing this as a fascinating drama, I also start to see the documentary as a story of the institution and the network. I note how Garbus grants us fascinating insights into the actors, the interactions and the multilayered processes of news in the making.
>
> Garbus reveals the New York Times inner workings through social upheaval in ways that Marx would recognise. She traces how a power shift combines with loosely formed social media networks to propel messages which short circuit the already stretched workings of an established institution. At one point, Editor Dean Barquet resets his editorial teams asserting the direct use of Twitter by his journalists '… is an issue for us *as an institution*.'[1] However, as the first year of the new presidency comes to an end a new equilibrium is found. Barquet's closing comments resonate with my focus on institutional theory, notably where he signals longevity and a return to 'taken for grantedness.' The cameras leave and the New York Times prevails
>
> Many more theses will be written on this extraordinary period in politics, and I hope I don't disappoint my reader to say, this is not one of them. I introduce the case of the New York Times to highlight that ideas and understanding about where and how the institution and the network meet are of ongoing interest to organisational studies. Although my research aims to take the alternate perspective to that of Garbus, by attempting to view the institutional environment through the experiences of those within network-like organisations, I trust their stories are just as engaging.

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[1] Garbus, L. (2018) The Fourth Estate. Showtime. Quote taken from Season 1 Episode 4, 35:30. Reviewed via SBS online 21 February 2021
https://www.sbs.com.au/ondemand/program/the-fourth-estate-the-ny-times-andtrump?play=1242878019693

1.1 Post-millennial meetings – engaging with the institution and the network

Just as Diane Garbus' documentary reveals how emerging networks can impact upon an established institution, such as the New York Times – my research aims to contribute new insights into meeting points of the institution and the network. However, rather than focussing on the institution, my research considers the institution from the perspective of the network-like organisation. In this way I aim to contribute to an understanding of how network-like organisations observe, and potentially contribute to, " … how … specific ecosystems of institutions change" (Davis and Marquis, 2005, p 333). To do this I propose that Research Centres located within Higher Education systems can act as a 'Janus object', to gain dynamic views of both institutional and network-like environments.

My motivation to explore the Research Centre as a network-like organisation arose from my experience in international research engagement, working across a number of Higher Education Institution (HEI) partners. Drawing from this background, I was stimulated to explore ways Research Centres apparently balance institutional interactions while also engaging with the wider Global Research System. Of interest too, was how support for globalised science was 'organised' within national Higher Education systems. However, it was notable from contemporary studies that Higher Education systems can be highly focussed on other external demands, such as; the rise (and fall) of international student mobility (Enders, 2004; Proctor & Arkoudis, 2017), the HEI's role in the knowledge economy (Olsen and Peters, 2005; Marginson, 2009) and the shift from state dependency to regulatory autonomy (Enders, de Boer & Weyer, 2013).

While exploring these interests in Higher Education policy and the Global Research System, I was also engaged with researchers with an interest in university rankings. My preliminary studies for this research considered how the (overt) response by HEIs to the Global University Rankings (GUR) phenomenon (see Harvey, 2015), contrasted with a less than enthusiastic response to the Global Sustainable Development Agenda (Power, 2018). While the institutional response to GURs concurred with views of the HEI's potential for faddish responses (after Weick, 1976; Birnbaum, 2000), these studies also suggested potential to explore more subtle, evolutionary changes within the institutional environment.

Two important fields of literature were formative for my own sensemaking and in orienting this research. Firstly, the literature on institutional theory informed views on both the 'institution' of Higher Education and the institutional relationship with informal forms of

organising (DiMaggio and Powell, 1983; Meyer and Höllerer, 2016). The second body of literature follows the emergence of the field of network science. This demonstrated the phenomenological nature of collaborative science (Albert and Barabási,1999; Newman, 2001), which was further explored in relation to ways science appears to escape the constraints of the institution (Wagner and Leydesdorff, 2005). My formative question then was - can the Research Centre, as a potentially network-like organisation, provide further insight into these complex institutional and network environments?

Work which also shaped my views of a shift in the Higher Education environment, includes Enders' note that; " … [there is] no longer a single society to which a university can now be expected to respond" (Enders, 2004, p. 363). This sense of fragmentation of the institutional environment and emergence of network-like organisations concurs with a view of an emergent "society of networks" in the 21st Century (Meyer and Höllerer, 2014, p. 1226). On this basis Meyer and Höllerer champion that the lens of institutional theory should refocus on 'organising', rather than 'the organisation.' This perspective also provided impetus for focussing on the more 'ephemeral' nature of the network-like organisation in relation to the institutional environment.

1.2   Network-like organisations in institutional settings - the HEI environment

To frame my research, I first develop a view of the HEI as the institutional setting. In particular I follow how 'the 'idea' of the modern HEI is grounded in the sociological foundation of Weber, Durkheim and Marx (after Giddens, 1971; 1985). I also consider the contribution of Darwinian perspectives which have been incorporated into views of organisation, including their 'evolutionary' attributes of survival (Cameron and Whetten, 1983), persistence (Zucker, 1977), structural flexibility (Weick, 1976) and adaptability (Cameron, 1984). These have all also been explored to 'explain' the HEI as an institutional form.

I also explore the HEI in broad philosophical and sociological terms. Work by Pederson (1997) highlights the HEI as a colonising institution, while Czarniawska, (2009) considers the birth of the London School of Politics and Economics as evidence of emergence of new institutional forms of the 20th Century. The social and symbolic role of the HEI continues to provide an 'ideal type' for studies, such as those which have documented the rise of the 'modern', corporatised form of the HEI (Biggs and Davis, 2002; Rouse, 2006; Frost, 2015). In their most recent iteration, the HEI is viewed as a 'globalised

type', as research intensive 'World Class' multiversities (Enders, de Boer, & Weyer, 2013; Enders, 2004; Marginson, 2009, 2017).

In linking this highly institutional view I also consider the role of the HEI as a 'theoretical informant.' In particular, HEIs have shaped 'new' institutional theory by serving as a model for modern institutional forms (Zucker, 1977). More conceptually, HEIs fit the neo-institutional view of a co-constituent of the organisation field which creates an "institutional life" (DiMaggio and Powell, 1983, p.148). This concept suggests HEIs form a population of organisations – an organisational field - which individuals and other organisations may become engaged in. At its broadest DiMaggio and Powell would argue that the dominant social context all organisation and individuals can only operate within or through an 'institutional life.' As noted by Zucker (1987), this concept has also been applied to provide insights into ways institutions, such as HEIs, 'create' their own 'environment.'

Martin (2003) helpfully unpacks DiMaggio and Powell's use of field theory to explain both interorganisational relations and the environment of institutions. This approach is linked to the Gestalt view of a population of organisations forming an environment where the whole is greater than the sum of its parts. Martin notes how this view also extends Bourdieu's view of social inter-relationships within situated perceptions of social space to the organisational level. Recognising HEIs forming a type of multiverse or 'institutional field', also provides an appreciation that 'incursions' by a network-like organisation, such as a Research Centre, could have interesting outcomes (after Davis and Marquis, 2005). These perspectives helped to inform the theoretical lens for the research.

1.3 New populations in the organisation of science

The further layer explored in scoping the research is the role of network-like organisations as representative of the 'organisation of science.' The collaborative outputs of research in certain fields of science have been demonstrated to obey power laws as 'scale-free networks' (Albert and Barabási, 1999), while simultaneously being highly interconnected as a multitude of 'small worlds' (Newman, 2001; Watts and Strogatz, 1999).

To establish a suitable 'Janus object' for my research, I selected the Australian Research Council's (ARC) Centres of Excellence Programme as the case for my empirical study. Inaugurated in 2001, the Australian CoE Programme funds a new cohort of CoEs every three years, with each CoE receiving seven years funding. The empirical study captures contributions from those in leadership roles from 17 CoEs with their experience covering the lifespan of the programme. This generation of network-like organisations allows an exploration of overlapping views as CoEs 'emerge' across multiple partner HEIs.

To contain these broad systems views for the research design I developed a conceptual model which places the CoE as a 'Janus object' in the overlays of the Higher Education and Global Research Systems. The purpose of the model is to focus on the potential observations of the dynamics in the overlays of the institutional and network environments. I base these overlays on a complex systems schema by Sayama (2015), which includes concepts which interface with institutional theory and views of the institution as well as extends to the field of network science. Sayama's schema also allows for a focus on emergence and self-organisation as 'indicators' of complex systems. This enables an exploration of the potentiality of the CoE as a network-like organisation in its own right.

The core literature brought together to develop this 'Janusian model' - the context of Higher Education systems, the HEI as an 'ideal type' and the potential for network science to capture network-like attributes of the research system – provide a suitable background for the empirical research. However, the review also identified two challenges in readily applying this model to a study of network-like organisations as a 'Janus object.' Firstly, an ontological perspective of 'network-like organisations' in relation to the institutional environment required further exploration. Secondly, the review identified that the concepts introduced in neo-institutional theory – in particular the view of the organisational field – had not been integrated with 'new' findings in network science or complex systems in more recent studies. This led to a further exploration to determine the potential to effectively apply neo-institutional theory with network science in the development of studies in complex systems.

These two challenges were explored through more detailed literature reviews. I first introduce the ontological review below and then provide a rationale for following current debates in institutional theory and seeking a closer alignment between theory and network science.

1.4   Ontological perspectives of network-like organisations

In developing the research design, the network-like organisation of a national Research Centre is conceived as both a relational object and one with adequate autonomy to act as an observatory of a complex environment. Although a shorthand has been proposed in considering network-like organisations as 'orgnets' based on perspectives of social media networks (Lovink and Rossiter, 2018) and 'netdoms' in relation to networks within institutions (Mohr and White, 2008), there is an apparent limitation to forming a suitable ontology for 'ephemeral' network-like forms of organising (after Meyer and Höllerer, 2014).

To explore these ontological perspectives, I first develop an overview of Research Centres as 'types' of 'organisations of science' through their historic development. I note how different types of Research Centres have been grouped over time, particularly in relation to the growth of national research systems (Ikenberry and Friedman, 1972; Geiger, 1990), and as an 'actor' in expanding the knowledge economy (Etzkowitz and Kemelgor, 1998). More recent studies are reviewed in relation to the Research Centre and the HEI as entities within the innovation 'ecosystem' (Autio & Thomas, 2014; Vargo, Wieland, & Akaka, 2015; Bogers et al., 2017). These shifting taxonomic views place the Research Centre as both an 'entity' and as a potential 'relational type' within the Higher Education system.

I also consider how science itself might have potential to shape the Research Centre as a network-like organisation. This is based on perspectives of the 'nature' of western science, from the formation of 'persuasive communities' (Allen, Qin and Lancaster,1994) through to considerations of the ontological commitment to science (after Quine, Smith, 2020; Potter, 2010). In looking at the way 'science' has developed institutional connections I follow work by David (2004; 2008) on early transactions with the state that established the principles of 'open science.' This allows a view of the Research Centre where the field of science and its relationship with the state may act as the primary informant of the mode of self-organisation.

Concepts which consider the evolutionary view of collective action (Ostrom, 2000; Etzkowitz and Kemelgor, 1998) and the organisation of international science as a complex adaptive system (Leysdesdorff and Wagner, 2008) are also considered in relation to the Research Centre as an object in the institutional environment. The more phenomenological aspects of science, such as the rise of 'post normal' science, as discussed by Nowotny, Scott and Gibbons (2001), explorations of 'big science' by Wagner (2019) and the role of 'big data' in science by Borgman (2015), are considerations of relevance to an ontological

view of network-like organisations as evidenced by the phenomenological aspects of globalised science.

I also consider the rather fluid 'nature of science' in the context of the institutionalised environment and the co-evolution of arrangements with the institution. This considers the adoption of Giddens' theory of structuration (Giddens, 1984) in relation to the social construction of institutional science (Latour, 2005; Mohr and White, 2008) and the nature of how the 'institution meets science' in understanding the HEI-CoE relationship (Lepsius, 2017).

In looking at the CoE as a Janus object I firstly note its potential to act as 'an observer' of the institution (after Searle, 2005). Given CoEs could be considered to enjoy a relative asymmetrical and transient relationship with the HEI, I also consider Whitehead's relative ontology of 'spacetime events.' These perspectives offer an alternative ontological view to that of the CoE as an 'organisational entity' (McHenry, 1997), and provide a means to interrelate the CoE as a less tangible organising form within the concepts of emergence in complex systems (Bruno, 2009).

1.5 Finding an institutional lens, taking a network perspective

The second challenge identified through the literature review was the limited application of institutional theory to consider complex systems and a lack of intersection with network science. To explore this aspect of the literature I first introduce the point – counterpoint discussion set out by the Editors of the Journal of Management Studies (2014), which highlights the 'dialectic' of institutional theory and the resultant tensions *within* the field. Here, I provide a brief overview of how the protagonists for institutional logics (Thornton, Ocasio and Lounsbury, 2012) opened up a challenge for the 'direction' of institutional theory which was debated by Meyer & Höllerer (2014) and Greenwood, Hinings, & Whetten (2014). While this research finds resonance with Meyer and Höllerer's perspectives, challenges from Greenwood et al (2014) also have relevance in locating the theoretical lens for this research.

The review also revealed that the founders of network science – while not troubled by the complexities of a networked environment – have similarly reflected on a suitable theoretical frame for their emerging field. In the case of network science this change was noted as a move away from big data modelling to more diverse approaches to "…understand the behavior of the systems that we perceive as being complex" (Barabási, 2009, p.413). In common then were both institutional theorists (Hinings and Greenwood, 2018) and network scientists (Watts, 2004) reaching back into their sociological foundations to determine a future direction for their field.

In tracing this debate, I refocus on reading 'The Iron Cage Revisited: Organisational Isomorphism and Collective Rationality in Organisational Fields' by DiMaggio and Powell (1983) from a network perspective. In 'The 'new' science of Network Science' by Watts (2004), which reconnects the phenomenological models of network science with their sociological foundations, I consider opportunities to trace connections in common through institutional theorists.

This review demonstrates the inherent thread of networks in 'new' institutional theory which were seen to be 'lost' in favour of the uptake of isomorphism (DiMaggio, 1995). Based on this exploratory review, I find potential to bridge these two fields, notably via contributions to both fields by Harrison White (Greenwood and Meyer, 2008) and Mark Granovetter (Watts, 2004). This reading established value to pursue a more detailed integrative review. This allowed the construction of a 'translation' of vocabularies between descriptive references in institutional theory and terms in network science as a means of bridging the language gap highlighted by Watts (2004).

1.6 Research Design and Research Questions

As noted, the literature review established three areas of value to developing the research design. Firstly, the adoption of an institutional theory lens, in particular through perspectives from 'new' institutional theory associated with studies of the HEI; secondly an ontological view of 'network-like forms' in relation to the institution and thirdly, the potential to extend empirical studies of the institutional field with a closer engagement with network science.

The literature review, which linked a view of the institution with empirical studies on Research Centres, provided signposts to studies of network-like organisations which informed the research questions and research design. Other literature of relevance to the research approach included those which reconsidered relational aspects of networks and how collective action shapes institutions (Mohr & White, 2008; Ostrom, 2000); articulated the sociological antecedents to phenomenological studies of networks (Watts, 2004) and considered the institutional role in research collaboration as models of complexity (Wagner and Leydesdorff, 2005).

Based on these formative perspectives and the Janus model as a conceptual frame for my research, the research design was developed using an iterative process through three studies: an integrative review of institutional theory and network science literature; a focus group with an international group of research professionals; and an empirical study of the Australian Research Council (ARC) Centres of Excellence Programme. The findings from the first two studies contributed to the approach taken for the empirical study of the CoE Programme and informed the analysis of findings. In turn the findings from the CoE study informed a closer analysis of the literature. An overview of the iterative development of the research design is shown in Figure 1.1 below.

Figure 1.1 Iterative stages and outputs of the literature analysis

Institution and Network Literature Reviews and Outputs
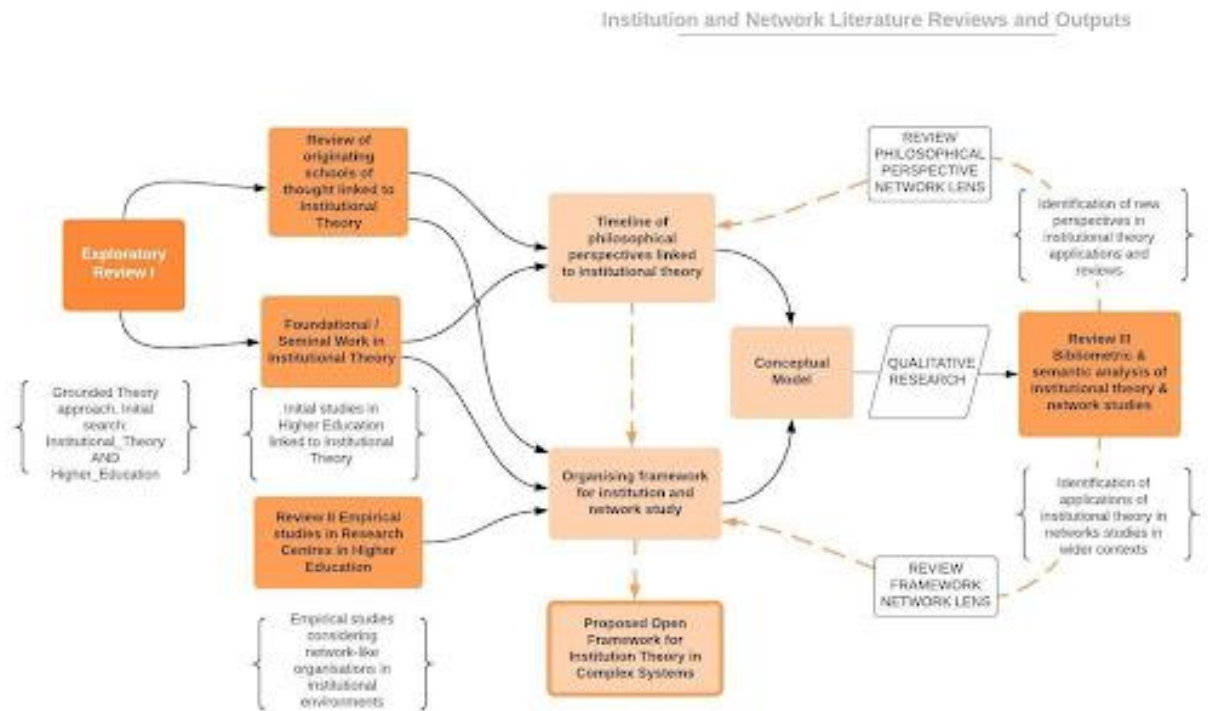
As shown in Figure 1.1 the output through the series of reviews and literature analysis was the development of an open architecture framework for application of institutional theory in complex systems and this is discussed in more detail in Chapter 4.

These considerations resolved the research design into the three core studies and the related research questions for each stage are shown in Figure 1.2 below. The figure also indicates the iterative nature of this design.

The overarching research question in setting the CoE as a Janus object was primarily:

To what extent can observations 'from' National Research Centres, such as CoEs, further our understanding of the institutional environment of the Higher Education Institution?

And secondly:

To what extent can experiences of the institutional environment, from the perspective of CoEs, inform an understanding of emergence and self-organising of network-like forms in complex systems?

Figure 1.2   *The core research studies and research questions*

Study 1
Through the literature review

To what extent can institutional theory and network science inform insights into the form and function of network-like organisations in institutional environments?

Study 2
Through the research professionals' focus group

To what extent are research professionals engaged in Research Centres able to describe their interactions with associated HEIs and other stakeholder organisations?

Study 3
Through the ARC Centres of Excellence case

What observations, interactions and experiences do CoE leads describe which provide an insight into the interplay between network-like organisations in the institutional environment?

In what ways can institutional theory and network science be applied in concert to interpret observations and experiences which extend an understanding of self-organisation of network-like forms in institutional environments?

To what extent do the narratives of those engaged in CoEs contribute insights into the emergence of more network-like forms in institutional environments?

1.7 Approaching a study of the institution and the network

Based on these perspectives from the literature, I adopt socio-constructivism as a mid-range theoretical position for the research (after Berger and Luckmann, 1966; Giddens, 1987). This relates to views of the social construction of science (Latour, 2005), allows for views of the network in institutional terms (Mohr and White, 2008) and collective action in institutional design (Ostrom, 2000). I leave open potential to identify either more network-like views aligned with neo-institutional theory (DiMaggio and Powell, 1983; Zucker, 1987) or more institutionalist views (North, 1990; Knight and North, 1997), to interpret both the nature of any institutional 'observations' or responses of the CoE.

As the empirical studies consider two relatively untapped fields – the research professional role in the Research Centre and the case of Australia's Centres of Excellence Programme - the approach is predominantly qualitative and interpretive. This aims to enable insights into network-like organisations, such as emergence and self-organisation, as described through contributions from those engaged in this environment.

In most cases in the literature on the organisation of science, including Research Centre studies, the emphasis is on researcher narrative and interactions. However, the rise of the research professional has been another phenomenon in the HEI research system (Berman and Pitman, 2010). The growth of national and international research management associations has allowed a mapping of the profession via global surveys (Scott and Kerridge, 2018) and exploration of their roles (Santos, Varela and Kerridge, 2021). The role of the professions is also of relevance to perspectives from institutional theory through their prospective role in 'structuring institutions' (DiMaggio and Powell, 1983).

Although this is the first external exploration of the Australian CoE Programme, my research was informed by other qualitative studies of equivalent national programmes which focus on perceptions and roles of the researcher, such as those in Canada by Bell (1996), in Norway and Sweden by Borlaug and Gulbrandsen (2018) and in the US (Boardman and Bozeman (2007). Based on these studies, a value was seen to allow a 'wider view' of the institution from the CoEs by inclusion of the professions allied to science.

Given limited prior studies on the role of research professionals in this context, I conducted a focus group with representatives from the International Network of Research Management Societies (INORMS) to support the research design. The perspectives contributed by an international group engaged in Research Centres and the institutional environments primarily aimed to inform the CoE study design. However, the high proportion

of direct interactions between the research profession with researchers, as noted by the focus group, affirmed a benefit in engaging both Research and Professional Leads in the CoE study to understand this apparent synergy.

Rather than looking at the level of practice of the individual scientist (as detailed by Latour, 2001), the research adopts a method outlined by Nicolini (2009) to consider a broader organisational practice setting by zooming in and zooming out and then switching lenses within a particular case. In this case, this approach relates to considering views of the institution 'from the CoE' and then asking contributors to consider the interactions through the layers of the CoE as a dynamic object.

In forming a method to consider accounts of interactions of the CoE which relate to how they self-organise and interact, I returned to the sociometric approach of the 'invisible college' by Crane, (1972, 1977). This aligns with reflections in network science to better understand "… the dynamics of the processes that take place on networks" (Barabási, 2009. p.413). In considering the CoE as an organising form, I note the limitations in applying bibliometrics as a methodology to understand the nature of science networks. In particular, I refer to recent problems flagged with extrapolations of bibliometrics to inform research impact policy (Cronin and Sugimoto, 2015). In contrast with the emphasis on 'big data' I also highlight a return to other eclectic data sources in the exploration of community networks (as noted in work by Lusseau and Newman, 2004).

Lastly, I provide an overview of the key methods applied to analyse the intersections across the three studies. This is informed by approaches which apply 'network pictures' as "… a research device to construct the actor's view of the network" (Ramos & Ford, 2011, p.477) and a framework which considers the role of stories or "collective rhetorics" as part of understanding network-like interactions in relation to the institution (Mohr and White, 2008, p.493). In the analysis of the CoE narratives I extend these concepts to develop 'network narratives' in relation to the set of network models outlined by Watts (2004). In this way the study design aims to capture a more dynamic view of the CoE based on the contributions of the participants.

1.8　　　Navigating the thesis

The following chapter considers the literature underpinning this research. The literature review considers the context of globalisation of the Higher Education system in the 21st Century and the continued evolution of the state-science-HEI relationship in the 'organisation' of science.

I approach the literature as 'walking the labyrinth', firstly, by exploring the HEI itself as the institutional setting, then considering the HEI-Research Centre relationship through historic studies of Research Centres as network-like organisations in national and global research systems.

This chapter develops two themes based on calls in the literature to further an understanding of network-like organisations; firstly, to consider ontological perspectives of the Research Centre as a 'network-like organisation' in relation to the institution. I introduce the Australian CoE Programme, which forms the empirical focus for my research, to consider whether the CoE as a 'type' of Research Centre 'fits' into historic taxonomic views. I present a number of prospective ontological views which I leave open to explore further in the empirical study.

Secondly, I explore institutional theory from a network perspective and then review network science through its sociological basis to consider how these can co-inform studies of network-like organisations in institutional environments.

This review establishes a model to inform the research design which places the Research Centre as a Janus object within the overlays of the higher education and research system under the umbrella of complex systems (after Sayama, 2015). However, the review determines that the links between network science and institutional theory require further study and this is developed in the integrative review as a separate study.

Chapter 3 provides the methodological approach for the three studies which constitute the data collection for my research. The sequence of data generation interlinks the three studies and follows a concurrent transformative design suggested by Creswell (in Robson, 2011), as being "guided primarily by the use of a theoretical design."

I first provide an overview of the approach to the integrative review based on Torraco (2005) which brings together institutional theory and network science as two bodies of literature for further exploration. I detail the process of selection of literature for this

review, outline the semantic analysis of common terms (after Landauer, Foltz and Laham, 1998) and the application of cluster analysis in NVIVO. This establishes subsets of literature for further analysis as 'more network-like' or 'more theory-like' in relation to foundational literature in institutional theory and network science.

I outline the second study, the focus group session, of research professionals as expert informants for the research. The session design follows a sociometric approach (after Crane, 1972) to gauge how individuals identify their 'network' and categorise 'institutional' interactions. The focus group also provided responses to a set of semantic questions which link to concepts of dualisms identified in institutional theory. Their responses demonstrated value in focussing on these potentially dialectical aspects of the Research Centre-HEI relationship in more depth in the CoE study.

The third study of the Australian Research Council's (ARC) Centres of Excellence (CoE) Programme forms the main empirical focus for this research. I first set out the basis for selection of the Programme as the unit of analysis for this study. I then detail how the study design follows a qualitative approach through semi-structured interviews but employs a pre-interview survey. This incorporates a revised semantic question set to explore potential for dialectical aspects of the institutional environment in discussion with the participants.

Chapter 4 presents the main findings and first level analysis from the three studies. Findings from the integrative review are based on an analysis of 79 papers from a possible 344 which considered both institutional theory and networks and were published between 2000-2019. A subset of papers identified in the cluster analysis as more network-like, are discussed in relation to the predominant methods applied to consider networks (after Burt, 2010; Bonacich, 1972) alongside their emphasis on isomorphism in relation to neo-institutional theory (DiMaggio and Powell, 1983). The findings align with reflections by DiMaggio (1995) that institutional scholars demonstrate limited engagement with concepts of collective organisation and network perspectives in neo-institutional theory. This suggested potential to explore to what extent neo-institutional theory and network science could work in concert to support complex systems studies.

The focus group findings identify a high level of co-interaction between research professionals and individual researchers. Data was also analysed from the perspective of symbolic interactionism (after van den Hoonaard, 2013) in relation to interactions with the institution. Findings from the pilot survey suggest a more open qualitative method would improve an understanding of interactions. However, the response to the semantic

questions proved valuable in gaining insight into perceptions of the 'Research Centre-HEI' relationship.

The rich material contributed by the 22 participants from the CoE study was first considered through an institutional theory lens. The first analysis of this material is mainly through an institutional theory lens, seeking to explore CoE-HEI interactions. However, a more suitable approach of considering emergent themes was then explored. This was developed through coding that was "… participant based" (see Blair, 2015, p.25). This analysis presents six emergent themes which were representative of CoEs irrespective of fields of science or their institutional base. Here I outline the use of VUE software to visually arrange sets of key statements from the transcripts in establishing thematic groupings. An overview of descriptions of how CoEs emerge and follow a lifespan through to closure or further iteration is also explored. The relationships within the CoE are also followed through an analysis of statements which specifically relate to the Chief Investigator role.

Chapter 5 provides a more detailed analysis which draws together key outputs from the studies. Firstly, the findings from the integrative review are considered in relation to the 'dialectic' challenge in institutional theory and the sociological considerations in network science. The discussion considers the tension between the agent/actor perspective and the 'agnostic' node in network science to 'test' the extent to which the two fields have diverged. This aims to establish potential for further application of the two approaches in concert in studies of complex institutional environments.

The second stage analysis of the CoE study, as informed by findings in the focus group, considers an overlay of the emergent themes and the potential to align with the organisational network groups detailed by Watts (2004) to form 'network narratives.' This provides two views of the CoE findings – firstly as an emergent form by considering network dynamics through the formation of the CoE and secondly as a self-organising form which responds to the institutional environment. In relation to understanding CoE function, I use work by Dodd, Watts and Sabel (2003) to consider relative robustness and information exchange in relation to the CoE narratives. In the case of highly interdisciplinary CoEs, I note particular challenges in establishment of cohesion, which resonates with other studies of CoEs suggesting a particular case for more detailed pragmatic research and possible intervention.

I develop a synthesis to highlight that CoEs can be recognised as pluripotential organisations, which demonstrate diverse network-like forms of self-organisation. I

propose that, in this way, the inter-related nature of the CoE Programme generates a 'pluriform topology' in the institutional environment. I also consider the unexpected 'experiences' and 'encounters' in the institutional environment which demonstrate emergence and align with the ontological view of CoEs as relational space-time events by Whitehead. In particular I demonstrate how those in CoEs often perceive 'encounters' or 'non-events', rather than formalising any clear inter-organisational (dyadic) relationship with the HEI (beyond institutional processes). Here I note how narratives of contextual challenges, noted by Weick (1995) as a collapse of sensemaking, align closely with 'navigations from the small world' modelled by Kleinberg (2000). I also discuss evidence of the potential for the CoE to 'infect' the institution in a network sense, through percolation (Newman, 2003), as the activity of the CoE emerges. I demonstrate this through the strong narrative of the development of gender policy generated by the COEs. This suggests that network-like organisations, such as the CoE, can develop autonomy within the 'odd' institutional environment, and yet, contribute to institutional change.

Finally, I provide an analysis of the Co-Lead narratives in terms of collective action. Here I consider their role from a network perspective by demonstrating their 'authority' in acting as 'information hubs' (after Kleinberg, see Newman, 2003). In addition, I note the synergy of Co-Leads, whose shared narratives suggest high betweenness – or effective information exchange - in network terms (Girvan and Newman, 2003, after Freeman,1979). I discuss how the role of information exchange resonates in ways that some CoEs act as conduits which could collectively be seen as a 'distribution network' to enable the 'stubbornly localised' to become 'global.'

In **Chapter 6** I synthesise a view of 'what' CoEs are, what they can tell us about the institutional environment and how they inform an understanding of self-organising forms which extends beyond the organising of science. In this way I propose a new vocabulary which borrows from network science to move the lexicon to 'forms of organising' as proposed by Meyer and Höllerer (2014). I discuss the analysis from the CoE study in relation to similar studies of populations of network-like organisations in relation to the institutional environment. In particular I look at emergent findings in common, particularly in relation to 'information flows', which could support an ontological view of network-like organising forms as distinct from institutions. However, I also note the CoE's potential to form and inform policy in other organisational settings and in this way act as 'proto-institutions' as defined by Lawrence, Hardy and Phillips (2002).

In formulating an approach which extends studies of the institution and the network within the frame of complex systems, I consider how linking sociological theories with more systemic or network methods have been addressed, such as work by Smith and Tracy (2016) on institutional theory, complexity and paradox theory and work by Modell, Vinnari and Lukka (2017) on institutional theory and actor-network theory. In parallel I note how network science considers paradoxical models and finds a need to bridge findings with sociological perspectives, such as Mak and Rapaport (2013), whose work on modelling the 'price of anarchy' relates closely to that of Ostrom on collective governance.

In extending institutional theory towards its application to complex systems studies I consider ways Martin (2003) links DiMaggio and Powell's view of field theory with Bourdieu's social construction of space. I apply this theoretical perspective to account for the spatial challenges CoEs appear to face through emergence in the institutional field. I then consider how my findings relate to neo-institutional theory, network science and Ostrom's work on collective action with reference to other sites of collective governance. I highlight similarities between this work and complex systems studies in 'emerging' fields of sustainable development, such as renewable energy governance, as evidenced by Genus (2016), Henriksen and Seabrook (2016) and Sjöstedt (2019). I also look at how recent work by Akcam, Guney and Cresswell (2019), who look at the potential to link grounded theory and system dynamics in qualitative studies, resonates as a novel approach to linking theories for studies of network-like organisations.

I resolve the analysis with the proposal of an open architecture framework shown in **Figure 6.1**. This aims to support applications of institutional theory in relation to network-like forms in complex environments. This extends substantive work by Scott (2004, 2008) who established the three pillars framework to guide applications of institutional theory by organisational scholars. The circular design of the framework references Scott's long engagement with an open architecture and "… the theoretical ripples" of institutional theory (Scott, 2014, p.136).

Chapter 7 provides the conclusion, particularly in relation to addressing the challenges put forward by Meyer and Höllerer (2014) on adapting institutional theory to 'complex design.' The conclusion also considers to what extent the study informs the proposition by Wagner (2019), that an understanding of the organising of global science offers wider potential for an understanding of social organisation. I also provide a summary of contributions of this research to theory and how findings have relevance to practice and policy.

In closing, I present a case which extends institutional theory and note further explorations in network science in relation to complex institutional environments. I note Mark Newman's continued search for network's Schrödinger's Cat and call to network scientists to stray outside their comfort zone and to 'get their feet wet' in developing further interdisciplinary approaches (Oxford Internet Institute, 2016). I consider how this call could also be taken up by institutional theorists.

Chapter 2 Walking the labyrinth

Reflecting on the literary journey

"… I associated everything with walking, with the experience of following the same routes over and over, discovering new details each time. And so, in the end, I decided to thread them all together in a sort of musical labyrinth, a little like stepping inside the twists and turns of the creative process, to understand how a musical idea can develop in multiple directions, and changing once again at the moment in which it is heard."

Ludovico Einaudi describing the process of creating his work, 7 Days Walking

Whether by intuition or chance, my 'assembly' of elements from the literature review and analysis took on a labyrinthine quality. What started as a mapping of contested dualisms and dialectic views in exploring institutional theory, became a more positive labyrinth of finding a way into the literature. By 'walking the labyrinth' which wanders in and then out through the literature there is potential to consider how the institution and the network might be explored in new and different ways.

Although the labyrinth is understood as an ancient ritual practice - often as a test or right-of-passage, such as the case of the Cretan labyrinth - it has also been adopted as part of spiritual practice and, more recently in secular society, as a practice toward resilience and wellbeing. In supporting therapeutic work, the labyrinth has been described as a "metaphorical stage", Hong and Jacinto, (2012, p. 620) and, in the case of its relevance to literature, is seen as "… a narratological mode for … textual experiments'' (Cox, 2018, p.339).

In literature reviews, the labyrinth has also been referred to in terms of navigating complexity. In their work related to psychological resilience, Ijntema, Burger and Schaufeli (2019) found an array of challenges, briefly noting that "… trying to establish criteria from our review was like navigating a labyrinth." In other examples, the labyrinth is granted additional powers in literature studies where the human-made labyrinth – referencing ancient Cretan mythology - has the ability, "…to entrap, nullify and transform" (after Foucault, Cox 2018, p. 347). I could similarly see myself falling into Rogers' take on the 'reader in the labyrinth', who is "…concerned with the meaning of things", but who might also be seen as an "a-Mazing reader" - ie as one who falls into the labyrinth of literature and sees it as a maze, a problem or puzzle to be solved (Rogers, 1982, p.32).

In the classical design, the labyrinth is laid out as a meditative practice, formed by a single, but ever inflecting path, intended to be walked - slowly and methodically. Certainly, there are puzzles, dead-ends and whole areas covered in layers of ideas which needed sweeping about and brushing off to form a continuation of the path.

But the literature review process, at its close, approaches the reflective intent of the labyrinth.

By starting outside the field of knowledge and walking toward and then away from the centre, returning each time with new information from other places, there is sensemaking and understanding in the performance of walking the labyrinth. Although I approached the literature in different ways at different points in the path, in drawing the literature together I provide this labyrinth as a framework for the literature review – trusting this also provides a helpful guide for the reader.

2.1　　　　Fields of focus

The interwoven threads of the literature, which I return to in the process of 'walking the labyrinth' throughout the research, are summarised in Figure 2.1 below. The literature review was guided by a proposition that the Research Centre within the Higher Education Institution (HEI) could provide dynamic views of both institutional and network-like environments. In this way the Research Centre was considered as a Janus object, to have potential to observe the institutional 'field' and "…provide useful understandings of the contemporary [post-millennial] era" of organisation (Davis and Marquis, 2005, p. 341).

To arrive at the empirical study of the Australian Centres of Excellence (CoE) Programme, which sets the CoE as the Janus object, I first step through the philosophical perspectives of the HEI as an exemplar of the complexity of human organisation. These views present the HEI as a persistent, yet adaptable, 'ideal type' which is able to produce its own institutional environment (after Cameron and Whetten, 1983; Zucker, 1987). The range of sociological perspectives of the HEI are considered in order to clearly distinguish the institution from the CoE in focus as a potential "… novel … ephemeral and fluid form of organising" (Meyer and Höllerer, 2014, p.1226).

The review then considers studies of the Research Centre as a relatively recent organisational form in the HEI environment. The co-evolution of the Research Centre with the Higher Education System is considered in relation to national systems of research as the 'institutional domain' (Enders, de Boer, & Weyer, 2013; Enders, 2004; Marginson, 2009, 2017). However, I also note how Marginson extends the institutional domain beyond national systems and characteristics, suggesting "… both states and universities must position themselves to advantage within global systems" (Marginson, 2017, p 242).

From here I consider a number of possible ontologies of the 'Research Centre' by looking at studies which consider the establishment of Research Centres as aspects of national development (Ikenberry and Friedman, 1972) through to sources of regional innovation. I also consider how these views of the Research Centre relate to understandings of transactions between science and the state (after David, 2008) and the phenomenon of 'self-organisation' of global systems of science (after, Wagner, 2019). I use these two perspectives to introduce 'Centres of Excellence' as a particular organisational form of national research. In linking these empirical study of the Australian Centres of Excellence (CoE) study, I also relate how the CoE has largely been considered in terms of relative value to existing national systems of science.

Finally, the literature review considers the theoretical lens for the study in relation to progressing a study of the institution and the network. This considers the HEI as a source

of scholarly exploration throughout the development and applications of 'new' institutional theory (Weick, 1976; Zucker, 1977, 1987; DiMaggio and Powell, 1983). The literature also considers potential for neo-institutional theory in particular to engage with studies in complex systems through its inherent perspective of the 'organisational field' (Martin, 2003; Davis and Marquis, 2005).

The final step considers both findings and reflections in network science which note the scale-free nature of some collaborative networks in science, but call to better "…understand the behaviour of the systems that we perceive as being complex" (Barabási, 2009, p.413).

The literature review resolves in formation of a model of the Research Centre in Higher Education systems as a potential 'Janus object.' This model also conceptually places the CoE as both an 'incursion' in the institutional environment (after, Davis and Marquis, 2005) and an emergent object in a complex system (after Sayama, 2015).

Figure 2.1   Literary domains and fields of focus

Studies in Higher Education

Institutional responses to the global environment
HEIs & their relationship with global science

Globalised Research: Context & Complex Systems

Changing context of science in society.
Research Systems & 'Ecosystems'

Research Centres in HEIs

The Case of Centres of Excellence as models for network-like organisations

Human organisation

Philosophical foundations in the social sciences

Network Science

The phenomenon of global science networks
Links with institutional theory & sociological basis of networks

Institutional Theory

Neoinstitutionalism
Collective Governance
Network concepts in institutional theory

The sociology of science

The role of science in human organisation & institutional development
Interactions of scientists & professions allied to science

2.2   Philosophical Grounding – The triumvirate, Darwin and institutional theory

The foundations of organisational studies offer an important starting point for exploring network-like organisations in institutional environments. In grounding the study, I provide a brief overview of the sociological perspectives of relevance to this study, particularly through Giddens' interpretations of the contributions of Marx, Weber and Durkheim (Giddens, 1971, 1985). However, I add Darwin to the 'new' triumvirate of sociological theorists, as noted by Bierstedt (1972), to allow for the evolutionary and ecological turn in understanding human organisation.

Lenski similarly describes Marx, Durkheim and Weber as the "holy trinity" in generating their own societal taxonomies, which were strongly translated into the 20th Century (Lenski, 1994, p.8). As a natural scientist, Darwin is generally placed 'outside' the core of modern sociology. But his profound influence on organisational studies is evident, particularly in neo-institutional theory where the concept of 'institutional life' suggests a world created, experienced by and, in turn, influenced by forms of organisation in an ecological sense (DiMaggio and Powell, 1983). While Lenski is noted to also consider Darwin in establishing an ecological / evolutionary taxonomy to account for the history of change in societal structures (see Nielsen, 2004), Darwin's 'natural evolution' was at odds with the irresistible view of human progress made evident by the industrial revolution. As Lenski notes, "…to lump contemporary industrial societies together with other 'civilised' societies, such as Ming China or Antonine Rome … was no longer defensible" (Lenski, 1994, p.12).

While Darwin would suggest technological prowess is no guarantee of survival of a species, Darwinian ideas continue to resonate in relation to understanding the nature of human socio-technical revolution. Taylor and Dorin describe the publication of 'On the Origin of Species' in 1859 as akin to today's environment of ideas. They note this period as an "… intellectual powder keg [into which] Darwin was about to drop a lit match" (Taylor and Dorin, 2020, p.18). Here they consider Darwin's contemporaries - James Babbage and Ada Lovelace, Mary Shelley and George Elliot - as precursors to our contemporary socio-technical context, of which global research is now an inextricable part.

Naturally it is only possible to provide a sketch in linking these philosophical positions to my research of the interplay between the institution and the network. Here I hope to provide a 'feel for the landscape' based on others who consider these foundational voices in depth. I briefly outline key views on the interrelationships of Darwin in relation to the 'triumvirate' to consider how their ideas entangle to inform perspectives on the institution and the complexities of the institutional environment. The interpretations of Darwinian

perspectives in institutional theory are also considered, particularly through the further exposition in relation to ecological networks, organisational populations and complex systems.

A reading of other foundational sources, which informed the theoretical basis for this research, is 'plotted' across a taxonomy of social types based on Lenski (1994) in Appendix I.

2.2.1 Marx and materiality

Although Marx and Darwin never met, their correspondence demonstrates Marx's high regard for Darwin, particularly through his direct engagement with Darwin's work *On The Origin of Species*. In contrast, Darwin is noted to acknowledge, rather than embrace Marx – noting on receiving a copy of Marx's *Das Kapital* "… I _ wish I was more worthy to receive it, by understanding more of the deep and important subject of political economy" Colp (1974 p.334). While Marx refers to Darwin's work as "epoch making", Colp also notes Darwin's reticence in associating himself with the atheistic nature of Marx's *Das Kapital* (Colp, 1974).

While Darwin steadfastly retained a focus on the biological universe, Marx sought to explain the history of upheavals of human society as the source of societal evolution. While admiring Darwin's scientific approach as a reinforcement of his approach to materiality, Marx viewed Darwin's reference to Malthus in explaining 'competition' as a phenomenon which altered populations, as limiting when it came to human society. The concurrence between Marx and Darwin, as well as their points of divergence, are important aspects in the development of institutional theory. In Marx's view the distinctive 'social history and economic life' of man, attributable to the use of tools, was the driving factor allowing 'human progress', to occur at a faster pace than the "… changes in biological characteristics and natural environments" (Runkle, 1961, p.111).

Marx's proposal for the apparently rapid changes in human society were based on a dialectic materialism (see Schmitt, 1988) which links to a basis in institutional thought. Dialectic materialism proposes that social ideas and theories, once legitimised, grant them a socially constructed form of institutionalisation, until another idea supplants the former case. Although the dialectic goes against a logic which some find challenging (Schmitt, 1988), Giddens suggests this dialectic view follows a form of evolutionism according to Marx's 'world growth story.' Giddens notes this as an acknowledgement of Darwinian ideas which Marx engaged as a potential to capture "… adaptive mechanisms" (Giddens, 1984, p.243). Of relevance to this research in considering modes of organising are Marxian

concepts, also noted by Engels, that "…the world is not to be comprehended as a complex of ready-made things but as a complex of processes" (Schmitt, 1988, p.443).

2.2.2   Durkheim and diversity

Scott (2014) attributes Durkheim's ideas as the antecedent to neo-institutionalism. In particular, this can be traced from the establishment of concepts of the social construction of reality by Berger and Luckmann (1966), through to Meyer and Rowan (1977) and Zucker's work on institutionalisation and cultural persistence (Zucker, 1977). Durkheim may have informed Giddens' structuration theory, which establishes evidence of social reinforcement of the place of institutions (Giddens, 1984). However, despite collating Durkheim's writings, reviewers suggest Giddens was "…less than enthusiastic" about Durkheim's work (Robertson, 1980).

Durkheim built on work by Auguste Comte, which clearly translated Darwinian concepts as *social evolution.* However, he made the distinction that complex human society was not deemed reducible to a purely biological/physiological existence, but was a result of collective actions of individuals (Tiryakian, 2009, p.80). In this way Durkheim aligned with Marx in considering the role of 'social forces', rather than more evolutionary views linked to 'mere' biology in relation to societal change.

However, Durkheim drew on ecological concepts when he observed that the division of labour acted to alleviate competition as population density increased (Hawkins, 1996). He also borrowed from ecological concepts where he saw society itself created continuity and order through obscurity of actions of the *"… conscience collective"* (Giddens, 1972, p.54) and arriving at a *"… preponderance of organic solidarity"* (Giddens, 1972, p.141). Durkheim is also noted to have interpreted Darwin in relation to a struggle for resources in human society (Giddens, 1972). For example, Durkheim's view of 'role differentiation' in society was seen as equivalent to Darwin's observations of speciation and adaptation to new environmental niches.

Durkheim's methodological approach to sociology is grounded in studies of populations in ways that also relate to Darwin's prospectus. In particular, his seminal work on suicide notes institutional effects and a sociological consideration of connectivity to account for incidence of suicide in a community. While noting limitations with Durkheim's methods, researchers continue to note the "…nuance and richness of Durkheim's insights" (Mueller et al, 2021). In this way Durkheim relates to this research through his efforts to connect interactions and the effects of institutions on more network-like social connections.

2.2.3 Weber and selective advantage

Weber's dominance in informing institutional governance has directly influenced European states and their colonised territories. In particular the adoption of Weber's "detailed descriptors" for public administrators helped enshrine the British civil service as a professionalised body (see Race, 2003). This codification was central to Weber's view of the rational, structural organisation, which he coined as 'the ideal type.' This concept proposes such an organisation can be explored both historically and in contemporary contexts to understand societal development (after Lutzker, 1982). In this way we can borrow from Weber to consider the HEI as an 'ideal type' in this case.

Weber's thinking about the balance of power between the political class and their associated administrative class, has had a pervasive influence on concepts of rational leadership. Here, Weber sees power relationships as "… 'substantive rationality' over 'formal rationality' in relation to policy-making" (Race, 2003, p.224). Weber's 'iron cage', interpreted as the constraints of excessive efficiency and the rise of the professional bureaucracies, came to be famously translated and reinterpreted in neo-institutional theory (DiMaggio and Powell, 1983).

In this way Weber is generally considered to have rejected the idea that Darwin's work usefully links to observations and operations of 'modern' human society. Runciman notes that Weber "… could never have accepted Marx's claim (*as expressed in Marx's letter to Lassalle of January 1861*), that Darwin had made it possible to put the idea of class struggle in history onto a natural-scientific footing" (Runciman, 2001, p.13). Weber also countered ideas around network-like potentials in society, as proposed by Savigny's *Volksgeist*, as a 'supra-individual whole', proposing instead that "… novel forms come about through individual initiative" (Runciman, 2001, p.15). However, Weber's Protestant Ethic also emphasises that substantive rationality occurs at the collective level, noting that "legitimate order" is "… based on explaining the relationship of ideas and the structuring of social action" (Lepsius, 2017, p.49).

Although Weber has handed down a view of the rational and economic institution, Nau suggests there is "… no explicitly formulated general institutional theory in Weber's work" (Nau, 2005, p. 126). However, Weber's work does have some Darwinian signs. Nau suggests Weber's thesis on economic institutionalism is based on "… the evolution of institutional arrangements" (Nau, 2005, p.128). Mesia-Montengro (2018, p.111) notes that Darwinian principles can be interpreted at the level of group or class as proposed by Weber, for example: "Unlike Durkheim's work and his altruistic view of religion, a Darwinian

approach will put religion [as an institutional system of authority] at a competitive advantage." Runciman also suggests that Weber considered Darwin's concept of individual or group selection when he describes the transmission of religious practices as a type of ongoing [cultural] evolutionary form (*Entwicklungsprozess*) (Runciman, 2001, p.17).

This brief introduction into the sociological foundations of the ideas of the western institution and the institutional environment aims to highlight their continued relevance. The different perspectives of Marx, Durkheim and Weber also serve as a backdrop to understand underlying tensions in the dialectic found in institutional theory. In linking to Darwin's evolutionary theory, we broaden the view of the HEI as a particularly persistent, but adaptable, institution, as evidence of its relationship to the dominant, neoliberal socio-political economy (Olssen and Peter, 2005; Frost, 2015). In Durkheim's terms we might see this resolve into a 21st Century 'ecosystem' of globalised education and research (Marginson, 2017). Noting the 'replication' of the HEI as a particular form, we can also recognise the population of HEIs as part of the 'global Higher Education system.'

The sociological view also informs an understanding of the 'dialectic' within institutional theory as a contest between these foundational ideas, which I discuss in more detail in the following section. This introduces the HEI as the institutional domain for this research in relation to these perspectives. Through the review I provide a closer reading of how institutional theory has also been formed around views of institutions of higher learning.

2.3 The Higher Education Institution through the lens of institutional theory

"… Universities are institutions that, in all societies, have performed basic functions which result from the particular combination of cultural and ideological, social and economic, educational and scientific roles that have been assigned to them. They are multi-purpose or multi-product institutions which contribute to the generation and transmission of ideology, the selection and formation of elites, the social development and educational upgrading of societies, the production and application of knowledge and the training of the highly skilled labour force."

Enders (2004, p. 362)

The Higher Education Institution fits Weber's definition of an 'ideal type.' A Weberian view concurs that an 'institution' can be summarized as an organisational form (among other social arrangements) with "… an undefined number of characteristics … that symbolizes durability" (Lepsius, 2017, p.49). Durkheim also notes the particular characteristic of institutions as *"…*the *longue durée* [which] … both pre-exist and outlast the lives of individuals born into a particular society*"* (Giddens, 1984, p. 170). Universities as an organisational form fit this mould particularly well. Cameron and Whetten (1983) cite a study by the Carnegie Council of Policy Studies which found that, of **66** western institutions documented in **1530AD**, **62** of those which persisted into the 20th Century, were universities.

However, Weber also distinguishes institutions in the sense of their rationality and formality. In particular, the potential to establish rules of law is interpreted as one of Weber's important "…explanatory variables for understanding society" (Sterling and Moore, 1987, p.67). The categories of "ideal types" developed by Weber, relate to accounting for how rules are set, suggests a differentiation of levels of autonomy which can be considered as more or less formal and more or less rational (Sterling and Moore, 1987). This view of the rational and formal was a foundation in institutional theory which Douglass North extended to explain the rise of western civilisation, considering the "… relationship between legitimacy and efficiency" (Faundez, 2016, p. 374).

Central to the empirical case for this research is the proposition that the CoE might observe the HEI as an institutional form while concurrently self-organising within the institutional environment. However, as an 'ideal type' the HEI also acts as a reference for understanding the development of institutional theory. In this section I aim to establish an explanatory view of the HEI from which to understand or reference observations noted in the empirical study. In particular I consider how the HEI allows a site for multiple views of institutional theory.

In Figure 2.2 below I provide a spectrum of theorists based on the literature presented here, noting their contribution to institutional theory and perspective in relation to the HEI. To the top of the diagram I present the informants of institutional theory with a more Weberian perspective. To simplify, these adherents view the institution as a form of social order. Dominant social institutions are established through particular sources of power – the Monarchy, the Church, the State, which, once established, 'act' to "… structure human interaction in a world of uncertainty" (Knight and North, 1997, p.214). This 'institutionalist' view generally attributes the formation and further evolution of such institutions to individual rationality, either through power, the structure of law or some legitimising process. The power of symbols, re-enacted in the institution through rituals, are also seen as important. In more recent times the Multinational Corporation (MNC) has also come to be viewed as a dominant institutional form (Davis and Marquis, 2005).

'Neo-institutional' adherents allow for more ecological or evolutionary views of institutional formation and persistence. Here interactions, processes and populations of organisations may all allow for 'phenomenological states' in the formation of organisations. In this view institutions are potentially created and perpetuated over time as a culmination of normative processes (Giddens, 1984), through the outcome of mindless cognition (DiMaggio and Powell, 1983) or through establishment of more cybernetic (Birnbaum, 1989) or autopoietic states (Maturana and Varela, 1991).

Ostrom and Weick sit somewhere in between these dualities. Ostrom for her perspectives on collective action which later aligned with Giddens' structuration (Ostrom et al, 1992; Ostrom, 2000). Weick through his concept of loose coupling in educational systems which allows a particular potential for adaptation (Weick, 1976, after Glassman, 1973). Weick also extends the focus we place on symbols in retaining organisational order, but highlights the 'ambiguity' of the institutional environment by observing what happens when 'sensemaking' fails (Weick, 1985).

New variants of institutional theory have emerged (perhaps diverged) which may account for either perspective. This includes the Theory of Institutional Design (Goodin, 1998), which tends toward the 'institutionalist' concept of rational social construction through socio-political discourse. In contrast, the Theory of Institutional Ecology (Abrutyn, 2012) proposes a view of ecological dynamics based on work by Hannan and Freeman (1977). This closely relates to neo-institutional theory introduced by DiMaggio and Powell (1983).
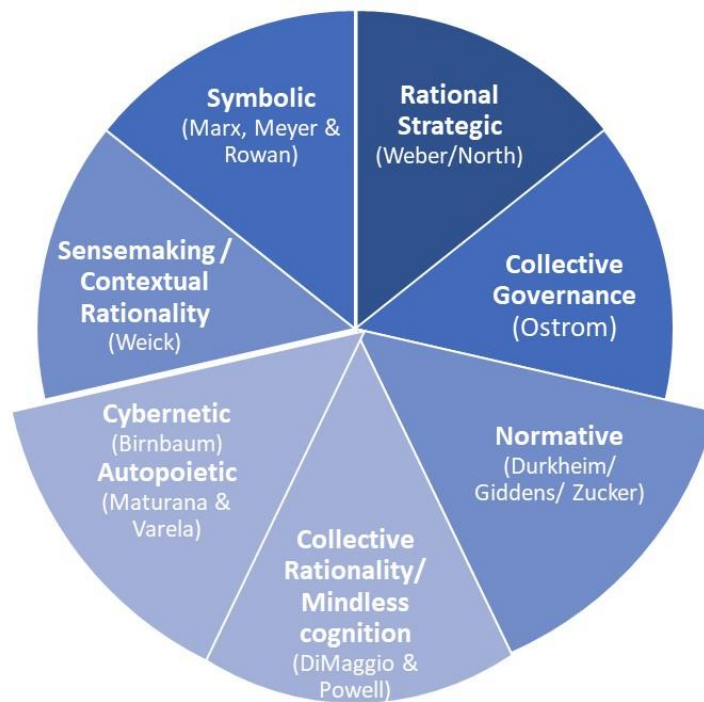
Wanda Stachiewicz (1964) provides insight into the strength of 'the idea of the university' in the history of Jagiellonian University. Even as the university was being systematically and brutally dismantled by the Nazis in 1939, the academy and students found ways to continue through mutual agreement. While this social construction could account for the persistence of the institution, the emergence of the 'secret university' following disruption could also be considered as Durkheim's re-ordering through *organic solidarity.* The formation of the 'secret university' suggests that the "institution" exists beyond any recognisable form of physical place and structures. Conversely a belief 'in the university' and re-enacting the rituals of teaching could also be seen as an aspect of Weber's secular rationalism, supplanting other religious practices which were also being suppressed.

Internal disruption and ideologically driven change can also impact the natural order of the institution. Ďurčansky and Dhondt (2014) document the thwarted centennial celebrations at Charles University in 1848 and again in 1948. In 1948 the 'ideological distortion' of communism, which expunged a number of high-status academics, was effective in disrupting the symbolic universe. Capitalising on the communist take-over, student activists used the jubilee event - as an international and symbolic event at the *Karolinum* - the ritual centre of the University – to coerce Odložilik, the university historian, to rewrite 'the Idea' of the university. However, over time the more 'normalised' operation of the University has returned as part of the European project.

These rather extreme cases demonstrate the high social establishment and symbolism, particularly of ancient institutions of higher learning. But more recent cases, such as the steady extinguishing of the European University in St Petersburg, show similar signs of persistence through its academy. After having their licence revoked the rector is quoted as saying, "… I feel trouble and pressure, but I'm trying to move forward. I just finished a book. I just went to a conference in Helsinki. We are carrying on with some hope" (Kelly, 2017). By all appearances this young institution has survived by adapting to the political environment.

The HEI then fits the view of a symbolic universe through a set of beliefs. These are sets that "everybody knows" and relate to further sets of social actions which "everybody takes for granted" (Zucker, 1987, p.443). The uniquely situated and symbolic social role of universities in serving the 'history of ideas', gives particular potential for those involved in the university to construct and reconstruct their own 'symbolic universe' (after Marx, Berger and Luckmann, 1966). This concept of the recursive nature of the HEI is represented in Figure 2.3 below.

Figure 2.3   *The HEI as a self-referencing system (after Marx in Berger and Luckmann, 1966; Bates, 1997)*
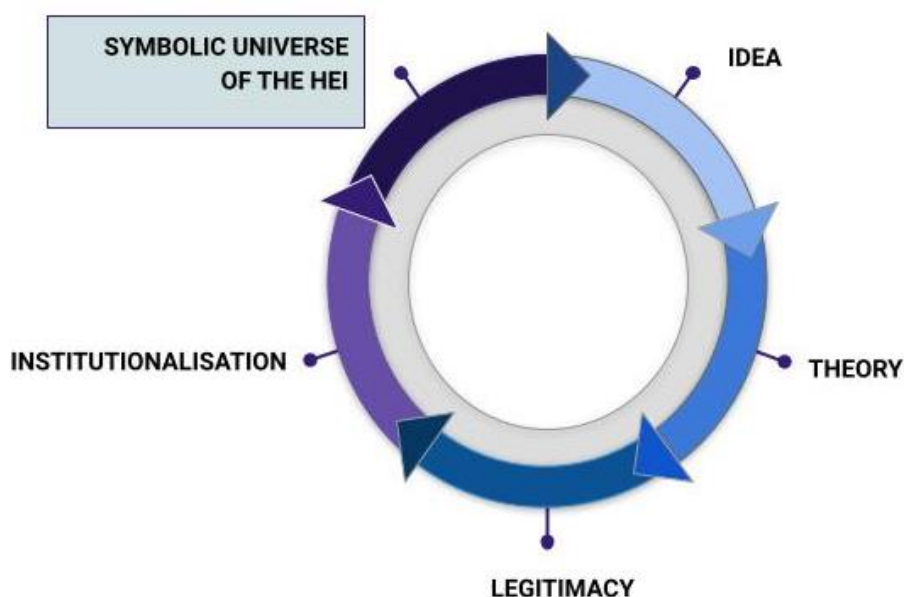
Although we see in these cases Marx's social upheaval and the particular impact on institutions, they equally serve as examples of adaptation and examples of Darwinian 'survival' as 'the institution' readily reverts to its more network-like constituents of academics and students. The modern role of research professions allied to science being re-employed in institutional roles is of interest here in relation to what extent they grow the 'idea' of science or the academy. An alternative is that they simply serve to grow the institutional core. In their study in Australian institutions Berman and Pitman ask whether the growth in research (PhD) trained candidates taking up roles as professional staff points to a benefit for university research or

simply represents a more structural, corporate institutionalism as an "…undervaluing by the institution that produces them." (Berman and Pitman, 2010, p.166).

These concepts are an important element in considering the nature of the university for this research. Firstly, through an understanding that the 'idea' of the university contributes to a creation of its own institutional environment (Zucker, 1987). Secondly, as an institution of 'ideas', the HEI is seen to provide a particular self-referencing model of legitimisation.

2.3.2   The evolution of the HEI

Enders' extensive definition of the university also gives us some insight to its evolution. Hearn (1996) notes the case of Harvard University as one of evolutionary persistence, through apparent adaptation. Although the changes between the founding form of Harvard College of the late seventeenth century and today's internationalised, research intensive university are self-evidently different, Hearn notes that pin-pointing the source of change is challenging.

Two examples in the 'life of the institution' provide different perspectives of change at Harvard. When Quincy describes the inauguration of Harvard's President in 1737 we see the symbolic universe, the institution enacted through the rituals of rational and moral men (Quincy, 1860). In contrast, Dava Sobel's recent retelling of the women who contributed to the science of the Harvard Observatory, signals the more diverse and unexpected events that steer institutions through their evolution (Sobel, 2016).

Despite an established historic view of incremental change over time, Hearn declares a more Weberian prospect for the HEI. Here he proposes that there remains potential for "… aggressive top leadership [to] build support for short-term strategic transformation" (Hearn, 1996, p.150).

Of course, the evolution of a single institution can be predominantly conceived as the changing complexity of co-construction by those people who pass through the institution (Giddens, 1984). Another view of evolution would be at the systems level where organisations themselves are viewed as populations. Here biology takes hold as organisations are viewed in terms of 'births and deaths' (Cameron and Whetten, 1983).

There is a need to also consider how the Research Centre is situated in relation to the HEI's evolution and the perspective of that evolution for this research. Many variations and intersections of scholarly and wisdom traditions have contributed to the formation of HEIs globally, and there have been periods of radical change in the form and structure of their development (Pedersen, 1997). The modern HEI derives from the Western European form of medieval universities, which were in various forms replicated globally through colonialism from

the 17th Century (Pedersen, 1997), modified to address the emergence of a modernising society from the 18th Century (Frost, 2015; Rice, 1970) or modelled on similar existing institutions in the 19th and 20th Centuries (David & Motala, 2017; Wang, 1997).

Although Cameron and Whetten (1983) note the survival of ancient universities as evidence of a 'population' of institutional resilience (as above), they retain the concept of the institution as a phenomenon firmly within the human social domain. For example, they note their use of biology as an **analogy** for observations of changes in the organisational form. They also conceive of the life cycle approach as focusing on "… evolutionary change in the sense that the development of organizations is assumed to follow an *a priori* sequence of transitions rather than to occur randomly or metamorphically" (Cameron and Whetten, 1983, p.267). Here they also distinguish cognisant (group) behaviour to move the thinking on institutional development away from the purely rationalist (individual), while still accounting for a human role in adaptation through the institutional life cycle.

However, this dynamic view of the institution has relevance in noting the group interaction within the institutional environment. Cameron and Whetten's analysis of life cycle stages of collective development also has relevance to considerations of self-organisation in the CoE study. However, as the institutional form evolved so too did national systems of Higher Education. Within this wider institutional frame, the individual, independent institution has become a 'global type.' As noted by Groucher and Woelert (2015), in the Australian case, national policy reform has resulted in an isomorphic institutional form modelled on the corporation. This system within a system effect is explored in more detail below.

2.3.3   The HEI as a system within a system

Of course, the Darwinian principle that evolution and adaptation is somehow consciously co-constructed in the case of human existence through institutions, but for no other species, might be stretching the analogy. A subtler distinction is how the natural (the non-teleological) world **is** (see Jain after Steinbeck and Ricketts, 2017), versus how the human (the teleological, inductive) world is understood. In organisational studies there is a subtle reversion to emphasise the human case as a purposeful and intentionally progressive act. This persists as a source of tension in institutional studies. However, a non-teleological view also allows a more agnostic understanding of the HEI as a system.

In principle the dualism of the mechanical and the organic is accommodated in classical sociology as two 'forces.' In classical philosophy both contribute to explanations about the overall development of the social world and therefore, the understanding of the formation of social institutions (Kant 2007 [1781]; Berger and Luckmann, 1966).

This dualism has been extended to consider the HEI on two fronts in relation to perspectives which inform institutional theory. Firstly, in the biological sense as considering the HEI as a complex adaptive system in its own right or as a population of globalised types which form their own 'ecosystem.' Secondly as institutional forms in the cybernetic sense that 'read their environment' in order to retain homeostatic order or as evidence of autopoietic systems which are wholly self-contained.

The development of systems concepts introduced the recognition of complexity to institutional theory. In particular, the theories of von Bertalanffy have relevance in taking a complex systems view across the HEI and CoE relationship (Bertalanffy, 1938, 1968). Bertalanffy approached the challenge of how "… normal science confronted … impasses as soon as it ventures into the realm of 'organized complexity'" (Pouvreau, 2013, p.856). This thinking started to highlight the inter-relationships between organisations as being relevant at a macro-level, particularly during the period of post-industrial and millennial globalisation.

In neo-institutional theory DiMaggio and Powell adopt the term 'institutional life' to indicate the environment created by social institutions (DiMaggio and Powell, 1983). Zucker also emphasises the organic survival of the institution in adopting normative order as a means to "…increase the flow of societal resources" (Zucker, 1987, p.445). Taking the ecological, population view, Abrutyn (2012. p.169) traces the influence of ecological thinking from Durkheim in relation to how organisations approach "…. resource scarcity within a given niche in relation to competitors." This view "… conceptualized populations of organizations as growing, stagnating, and contracting within resource 'niches' " (Abrutyn, 2012, p169).

More recently, ecological terms have been co-opted to define broader organisational frames. These include now frequently used terms, such as the 'financial ecosystem' or the 'innovation ecosystem.' Autio and Thomas (2014) explore the uptake of the term 'ecosystem' as a useful metaphor of organisational formations, noting DiMaggio and Powell's concept of 'an institutional life.' They also note the work in network science and its potential universal findings. However, they caution that the 'innovation ecosystem' may be a "…convenient catchphrase" (Autio and Thomas, 2014, p.2). Their resolution is to refocus on ways logic and strategy may have an effect on 'productive ecosystems.' In contrast, tying institutional theory to a range of systemic views is seen to have relevance for understanding the institutional role in relation to phenomenological findings of the global research 'ecosystem' (Wagner and Leydesdorff, 2005).

The 'institution as systemic machine' is a quite different view. This systems view of the autonomy of institutions can be represented as unconscious, self-contained (autopoietic) and/or as self-regulating (cybernetic) entities. As such, the model institution for the cybernetic case – Huxley College – is fittingly dreamt up by Birnbaum as a type of Metropolis. Unlike Hearn, Birnbaum recommends that in order for the HEI to avoid "Caesargenic outcomes", the best option is a 'cybernetic leader' who treats the institution as a black box and doesn't touch what isn't broken (Birnbaum, 1989, p.251). These metaphors and their related concepts are closely related to both systems theory and neo-institutional theory.

Systems theory perspectives are seen in the 'intangible forces' in Smith's *invisible hand* in market theory (Coase 1937, after Smith, [1759]). In his Theory of the Firm, Coase similarly imagines a town where "… business **men** will constantly be experimenting (so that) equilibrium will be maintained" (Coase, 1937 p. 404). Although there is a suggestion of human conscious action in 'experimentation', Coase also cites Smith's conception of the capitalist as "… a single cell in a larger organism, mainly unconscious of the wider role he fills" (p.389).

Stafford Beer's interpretation of the autopoietic institution is the biological equivalent of Weber's walled off iron cage. Stafford Beer characterises the contemporary university as an autopoietic "… iron maiden, in whose secure embrace scholarship is trapped" (Stafford Beer in (Maturana & Varela, 1991, p 70). Based on Matura and Varela's complex, self-contained neuron, Stafford Beer also extrapolates to the institution as operating at such a level of complexity that a single theory cannot hope to explain the entirety.

Although both the 'hidden machine' and the 'intelligent entity' are applied in theory to account for the intangibility of complex function, the dualism of Kant is seen to be dispelled in an autopoietic, homeostatic world. As Stafford Beer notes, the 'it' is not transcendental but something that is "… notified precisely with its survival in the real world", and enthuses that [the reason] "… autopoiesis excites me so much is that involves the destruction of teleology" (Stafford Beer, in Maturana and Varela, p.66).

In the case of the CoE and its relationship with the HEI this allows for an understanding of potential interactions. In relation to observations, this also allows a view of the institution as a 'green' site in ecological terms which can be observed for signs of change.

2.3.4   The HEI: an institutional actor or a node in the network?

Two final views of the HEI considered here are, firstly whether the HEI holds prospect as an agent for change or whether the HEI is simply a highly networked form interconnected with many other objects and organisations. In her consideration of the emergence of the London School of Economics and Political Science (LSE), Czarniawska (2009) notes the arrival of a 'new' institution in London. Czarniawska considers both the actor network as instigators of the School and the subtle emergence of the institution itself through a period of rapid social change. She also notes, via the continuation of the LSE, that "… an institution can be seen as a macro actor of longstanding" (Czarniawska, 2009, p.424). However, Czarniawska also suggests the LSE became an 'extra-logical object' which fits with Latour's concept from Actor Network Theory (ANT), noting that "… love is a necessary requirement … for the macro actor … to survive" (Czarniawska, 2009, p.436).

In the case of the LSE the template of the classical university was rejected to focus purely on the (modern) social sciences - but which, as the institution grew and took on more complex demands, would today be seen as similar to other institutional templates. The concept of the actor here and Latour's view of its affective form, also speaks to the establishment of the 'idea' of the new university. Other HEIs formed in the mid-19th Century are of a similar type. University College London and the University of Melbourne are other examples which 'fit' a 'new' social milieu of an industrialising society. Both eschewed the classical form of teaching and emphasised secular over church-based scholarship.

However, there is some jump from considering the institution as an actor to accepting the institution as a node in the network. Interestingly, in the case of the CoE Programme, the partner HEIs are referred to as 'nodes.' This view suggests inter-organisational connection via the HEIs, but could signify institutions co-opting a network language. The term 'actor' has institutional currency in cognisant agency, even suggesting an embodied strategic purpose. However, the 'node', in strictly network terms, is not cognisant of any social overlays but serves an agnostic junction for connection with other nodes. In Czarniawska's interpretation the institution as 'actor' also potentially has a role in Latour's Actor Network.

Abrutyn (2012) highlights a tension in organisational concepts moving from an ecology of actors (people) to a network of 'organisations.' This changing field of focus in moving through a network is also well explored by Latour (2005). For example, Abrutyn notes "… individual *and* corporate actors may find diversifying their commitment produces a greater amount of reward than had they committed to a single institutional core" (Abrutyn, 2012, p.173). Holding a focus on the 'actor' can therefore be seen as challenging in complex institutional systems.

References to network-like characteristics are commonplace in institutional theory, particularly when suggesting 'behaviour' of, or in relation to, the institution. In considering the HEI through the lens of socio-political ecology, Bates refers to 'linkages' in considering the social links of institutions (Bates, 1997). Weick also lists examples of network-like behaviour in relation to loose coupling including the view that "… richly connected networks in which influence is slow to spread and/or is weak while spreading" (Weick, 1976, p.5). This aligns with the network view of social cohesion. Abrutyn (2012) incorporates the 'rule of proximity' as a spatial consideration in the institutional environment.

Varela, Maturana and Uribe (1974 p.188) also initially described autopoietic organisation in network terms as systems which "… (i) participate recursively in the same network of productions of components which produced these components, and (ii) realize the network of productions as a unity in the space in which the components exist."

Zucker notes how contagion, in this case of structural elements, is transmitted through HEIs. This concept notes how these more network-like forms, which are seen to be generated by the institution, also become fixed over time:

> "…Already institutionalized elements can "infect" other elements in a **contagion of legitimacy**. For example, universities can create new departments, simultaneously creating new structures, new knowledge that is defined as expert, and new sets of categories to which individuals are allocated. It is paradoxical that: Institutional elements are easily transmitted to newcomers, are maintained over long periods of time without further justification or elaboration, and are highly resistant to change" (from Zucker 1987 p.446).

These examples provide an overview of how the Higher Education Institution has been considered by some of the key institutional theorists throughout the 20th Century, with some indication of the philosophic foundations which link these considerations to the thread of network concepts. As we can see, the development of institutional theory throughout this period took on emerging ideas from evolutionary and ecological biology, as well as seeking references from other findings in the natural sciences.

Taking Zucker's reference to the formation of 'new structures' in relation to the institution, we can see how institutional theory is also informed by a range of conceptual ideas which have been explored in further detail in network science. However, the collaborative self-organising nature of science is seen to generate originality as a primary focus (Mohr and White, 2008). The nature of the science collective and the collaborative networks of science at scale, can also be viewed as alternate forms of self-organisation (Wagner, 2019). The next section first looks at the emergence of the Research Centre, its relationship with the HEI and then explores the nature of the science collective to consider how the CoE might also 'fit' within the institutional environment.

2.4　Research Centres and the (re)organisation of science

"… I recall a meeting one day at which I was called upon to describe in a few short minutes the differences between departments, schools, colleges, areas, institutes, centers, Offices, and Laboratories. I struggled with this assignment, but each time I felt I was on the verge of finding even one characteristic which might conclusively separate one kind of a unit from another, I recalled more exceptions than were appropriate "to prove the rule"."

(Corbally Jr, 1973)

Just as Corbally struggled to consider the different 'institutionalised elements' within the HEI, any ontological view of 'what Research Centres are' challenges any effort to 'fit' the Centre of Excellence (CoE) within the institutional environment. The CoE was selected as a Janus object given its distinction from an internally established Research Centre. As a nationalised form of science organisation which span multiple partner HEIs, the CoE could potentially observe from both 'a distance' and hold proximity with a number of HEIs. In this way the CoE can be seen to be distinct from Research Centres of the 20th Century, which were seen to be 'formed' through university researchers and then universities directly being engaged by the State (see Geiger, 1990, p.7).

Tracing the origin of Research Centres and their inter-relationship with HEIs is also an important element of the study. This acknowledges both the potential for the HEI to actively interact and engage in the organisation of science but also to consider the alternate, that science-based interactions remain to some extent independent of the institution. Despite an apparent close association between the Research Centre and the HEI in 'modern' universities, the collectivisation of science is also considered an important aspect of the self-organisation of science.

To find an 'ontological' view which would allow the study of the CoE to be considered in relation to other 'Research Centre types', I first review studies which have considered the relative purpose of Research Centres. These have been described in more institutional terms as: an opportunity by society to harness the utility of universities to take on expanded, multidisciplinary activities (Ikenberry & Friedman, 1972); a means for interdisciplinary researchers to "... [negotiate] among several founders who jointly develop an intellectual framework that they wish to institutionalise" (Etzkowitz & Kemelgor, 1998, p.280), and as examples of "… new managerialism ... in the search for new, more effective and efficient ways of doing things" (Deem, 2001).

Although Etzkowitz and Kemelgor acknowledge Research Centres for their network-like potential as examples of "... collectivisation of academic science", they proceed

to note their more institutional characteristics - notably that "… Centres are also part of the shift of the university towards business formats. Their growth is making the university more complex" (Etzkowitz and Kemelgor,1998, p.280).

Rip (2011) views the Research Centre, including CoEs, as a new 'species' in the post-modern university and asks a taxonomic question – what do they look like? He notes discrete Research Centres may be enabled by the 'post-modern' HEI, as a means to embrace interdisciplinary and transboundary research beyond the institution. Importantly Rip (2011) projects that over time the CoE could become an institution in its own right through effectively supporting postgraduate education. However, Marginson suggests the 'World Class University' (WCUs) simply "…accumulates more size, parts and functions" to increase their "… social weight" (Marginson, 2017, p.251). This suggests the CoE may be a mere relational accumulation to assure survival of the *long durée* of the HEI.

2.4.1   Research Centres and HEIs – a transitional taxonomy

Despite the long-established social presence of universities[2,3], appearance of formalised Research Centres within HEIs is not described in the US until the 19th century (Etzkowitz & Kemelgor, 1998; Geiger, 1990). Early examples of institutional links to 'new' science structures include Harvard's Observatory, which was funded through public subscription in 1844 (Geiger, 1990; Sobel, 2016), and the association of the Royal Greenwich Observatory with Cambridge University (Jones, 1943).

However, at some point Research Centres became an increasing feature in relation to the HEI, particularly during the interwar and post-war periods of the 20th Century (Geiger, 1990; Ikenberry & Friedman, 1972). In the US this aligned with development of national institutions, particularly the State Land-Grant Universities, alongside an economic drive for research efforts which demanded an increased interdisciplinarity (Geiger, 1990). Agriculture was a focus of the land-grant universities established in each US State in the late 19th Century. State Water Research Centres were similarly established in each State the 1960s and later amalgamated to these Universities (Ikenberry and Friedman, 1972).

The increasing role of Research Centres as part of the HEI engagement in global research, particularly in the post millennial period, suggests a new 'Janus-like' duality, both in developing institutional entities and acting as nodes within a growing global network. The

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[2] Note in places I use the term university rather than Higher Education Institution (HEI), particularly to indicate an historic context as appropriate.
[3] The origin of the western university is considered to be the founding of the University of Bologna in 1088, now referred to as UniBo http://www.unibo.it/en

role of Research Centres in national research systems was also considered to "… make 'invisible colleges' or science networks visible" (Bell, 1996, p. 333, after Crane, 1972).

The association of Research Centres with HEIs in the US is noted as an outcome of both public and private intent (Etzkowitz & Leydesdorff, 1998; Geiger, 1990) The Hatch Act of 1887, which merged agriculture field stations with land-based universities, aimed to develop state infrastructure and economic development. Rapid growth of Research Centres is noted between the two World Wars as HEIs were enlisted as part of national research development (Geiger, 1990). Based on my search of the archive of the Royal Society, outputs by defined 'Research Centres' from within universities first appear in the Philosophical Transactions in 1972. These include articles from the Kings College Research Centre, Cambridge, and the Rheumatism Research Centre, University of Manchester.

Ikenberry & Friedman (1972) estimated about 5000 Research Centres and Institutes had developed in universities at the time of their comprehensive study in the late 1960s. By the 1980-90s larger empirical comparative studies considered the role Research Centres played, with the emergence of the 'Knowledge Economy'. These studies typically focus on evaluating Research Centres in relation to traditional university departments (Bell, 1993; Cooke, 2001; Harris, 1989; Kettunen, 2011), or provide more narrative accounts on Research Centres as emerging forms (Geiger, 1990).

By the 1980s Research Centres were accepted configurations of HEIs, particularly linked to the strategic "triple helix" model of research, education and engagement. But by the 1990s this term was being used to describe the inter-institutional arrangements between HEIs with government and industry. This was linked to the emerging knowledge economy (Etzkowitz & Leydesdorff, 1995; Etzkowitz & Kemelgor, 1998), which channelled funding to HEI research initiatives. These were described by Audretsch (1998), and similarly by Cooke (2001) as efforts to emanate Boston's biotechnology cluster[4] and Stanford University's link to the Silicon Valley IT boom.

More recent studies highlight the limitations of CoE initiatives to 'increase' research output. In particular, institutional limitations are noted in different political circumstances (Zgaga, 2014) and in terms of their value in more diverse contexts (Beerkens, 2009; Greene, 1989; Zgaga, 2014). More complex research arrangements are noted to be limited by factors such as low institutional capacity (Zgaga, 2014) or where institutions are seen as "…peripheral institutions in the international knowledge system" (Greene, 1989, p.47). This suggests that effective CoE Programmes are highly dependent on high levels of resources, existing institutional capacity and existing interconnected research systems. However, Beerkens also notes how international partner CoEs can highlight unique attributes and

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[4] This includes Tufts University and MIT - Massachusetts Institute of Technology

knowledge in science which can then be augmented via capacity in other institutions (Beerkens, 2009).

A number of studies also aimed to construct a taxonomy for Research Centres. An early taxonomy for the range of Research Units in HEIs in the US was proposed by Ikenberry and Friedman (1972). This was based on an organisational taxonomy linked to entrepreneurial theory of Becker and Gordon (1966). The term Organized Research Unit (ORU), proposed by Friedman and Friedman (1986) and developed by Geiger (1990), began to allow the formation of typologies of these research groupings as the numbers of new Centres and Institutes grew. Geiger (1990) took a retrospective view to see the taxonomic groupings of 'ORUs' as a co-evolution with the socio-political nationalisation of science in the US. Etzkowitz (2003) considers a similar period but from the perspective of the changing role of the lead researcher and their association with new organising forms of science.

Table 2.1 below summarises the range of studies considered here. I have suggested three broad categories in comparing taxonomic groupings which link to the overall perspectives of the HEI from an institutional theory lens. These are based on the level of constraint or formalisation of the organising type to the level of autonomy the organising type might express. As noted, these align with other organisational archetypes suggested by Becker and Gordon (1966) and other authors who separate out organisational types in similar groupings.

This table formed an organising frame for analysis of findings from the empirical CoE study.

Table 2.1 HEIs and Research Centres Relational Groupings: empirical studies and institutional views

	ORGANISATIONAL / NOMINAL GROUPINGS	Philosophical, Theory & Ontological Considerations	Group I (more constrained / less adaptive / more tangible)	Group II (more adaptive)	Group III (less constrained / less predictable / less tangible)
Institutional Theory Concepts related to HEIs	Application of Biological Theories to Organisation and links to Educational Institutions	**Based on inherent potential to operate, change, evolve**	**Autopoietic / Self Producing** (Maturana & Varela, 1991) (Mingers, 2013)	**Collective rationality** (Crawford & Ostrom, 1995) (DiMaggio & Powell, 1983)	**Loosely Coupled /** (Glassman, 1973; Weick, 1976) **Sense Making** (Weick, 1993)
	Application of Systems – Cybernetics to Organisation and links to Educational Institutions	**Based on self-regulation, potential for homeostatic control**	**Cybernetic** (Birnbaum, 1989; Birnbaum & Edelson, 1989)	**Complex Adaptive Systems** (von Bertalanffy, 1968) (Morrison, 2008)	**Adhocracy / Anarchic** (Hardy, 1991a)
Organisational Theory linked to Research Centre studies	(Becker & Gordon, 1966) cited in (Ikenberry & Friedman, 1972, p 34.)	**Based on resources and procedures (Entrepreneurial theory)**	**Complete bureaucracies**	**Truncated bureaucracies**	**Enucleated bureaucracies**
Research Centre Studies – National context	Descriptors & taxonomy of a continuum of institute types by (Ikenberry & Friedman, 1972) with their examples of types	**Based on configurations, temporality and legitimacy (identity)**	**Standard institutes** (Self-sufficient, large, bureaucratic, eg Materials Research Laboratory)	**Adaptive institutes** (Director - entrepreneur led with key staff eg Water Resources Centers)	**Shadow institutes** (Paper Institutes – "latent network of professional ties" eg Biological Science Institute)
	(Geiger, 1990) US Operational Research Unit (ORU) as Socio-Political Groups		**Pre-War (before 1940)** State Institutes	**(Cold)-War** National Institutes	**Post-War (Post-Modern)** Global Institutes
	Ikenberry & Friedman (1972, p.12) based on fields of research	**Based on utilitarian demands, socio-economic structural change over 20thC (mainly US focus)**	Agriculture, Water focus	Health & Defence focus	Biosciences
	Etzkowitz (2003, p.114) case studies on changing role of university, professorial roles & relationships		**19th Century** 'Land Grant' State Universities Liberal arts universities. Teaching focus; *Professor-Student dyad.*	**1930s Stanford/MIT** Adoption of entrepreneurial academic model *Quasi-firms – interdisciplinary seedbed* **Professor- Research Group**	**2000 Politecnico di Milano** Regional innovation *organizer – incubator model* Shaping organisations *Professor– project genesis*
	Interpretations in millennial studies of research groupings. Industry engagement and entrepreneurship.	**Based on political agency, purpose, commercialisation of outputs**	**'Smart State' Research Institutes Commercialisation Centres (Australia)** State-University - Philanthropic Triad Political-expert consortia eg (Dodgson & Staggs, 2012)	**Research Centres / Centres of Excellence (Canada)** Hybrid Research Organisations Professor – Company holder eg (Bell, 1996)	**Virtual Centres / Extra-institutional Groupings** eg (Davenport & Daellenbach, 2011) High Energy Physics (Newman, 1999)
Research collaboration studies – (based on the literature analysis)	Promotion of research links with industry, interdisciplinarity, growth in certain fields of global collaboration.	**Based on relationships, potential to form networks**	**Dyadic Triple-Helix** (Etzkowitz, 2008)	**Social Ties** Granovetter (1973) **Small World & Collaboration Networks** (Newman, 2001, Watts & Strogatz, 1998)	**Invisible College** (Crane, 1972) **Scale-free Networks** (Albert & (Barabási, 2001; Leydesdorff and Wagner, 2005).

The "ecosystem' view of globalised research in the 21st Century, which considers a range of organisational forms, is seen as a more challenging proposition to define. In their review of institutional research-based spinoffs (RBSOs), Mustar and others note the ever-changing states of RBSOs meant "… trying to design a single taxonomy able to follow spin-offs' evolution would be complex and inherently problematic" (Mustar et al., 2006, p.304).

In this emerging, more complex environment, the term 'Research Centre' was applied to describe "Regional Innovation Systems" (Cooke, 2001). This phenomenon of emerging networks formed by "… universities, research institutions, firms and leaders of (large) agglomerations interact at a growing rate in creating a solid knowledge-base for their city" (Matthiessen, Schwarz, & Find, 2002, p. 904). However, even this term has been revised more recently to encapsulate the dynamic nature of the research environment. Autio and Thomas suggest that today's Research Centre could now be functioning as part of an organic response which increases institutional survival and enables symbiotic relationships to form (Autio & Thomas, 2014).

Bogers et al. (2016) similarly describe the 'open innovation (OI) research landscape', as a shifting landscape of practice within virtual spaces and the real places. While Bogers et al do not mention the role of either HEI or science directly in their extensive review, they note the rise of the 'supra-national institution' as a site for further research. They also point to the pluriform nature of organising as outlined by Meyer and Höllerer (2014), by noting the proliferation of informal organisational forms, such as founder networks, makerspaces and virtual design platforms. In considering this array and potential of organisational types they, interestingly, ask "… how [do we] institutionalise and integrate such spaces in global innovation networks?" (Bogers et al., 2016, p.21).

In this context we can also view the CoE as a similar type of 'intermediary' organisational form as noted by Bogers et al (2016). This provides a further perspective about how types of open networks of science might be both institutionally enabled and constrained.

2.4.2　　　The Republic of Science, the Collective and the Institution

Science and the collective are fundamental to a discussion of research networks, but they can feel unrelated to aspects of the institution and institutional theory. Lepsius sets out a number of challenges in marrying science and the institution. Firstly, as we have seen, "... our understanding of institutions is weak" (Lepsius, 2017, p.49). Secondly, the institutional relationship with science is complex, as Lepsius also notes "… the university is an institution of science, and science is institutionalised within the university" (Lepsius, 2017, p.50). However, in relation to science itself, there is "... no self-contained organisational "Gestalt", meaning science cannot "... be captured by descriptions of its organisational form" (Lepsius, 2017, p.49). This implies an alternative mode must apply for understanding the self-organising nature of 'science' and its relationship with the institution.

Nevertheless, the institutional relationship with science has been a longstanding characteristic of its development – for better or worse. Sovereign patronage has been an important aspect of western science, from Charles II granting privilege to establish the Royal Society, to the less benevolent relationship between Galileo and Pope Urban VIII. David (2008) traces the early formation of collectives linked to science to the medieval period in Europe, when the granting of royal privileges and issue of patents enabled the early beginnings of 'open science'. Sovereign patronage also allowed for any potential scientific findings of value, which might otherwise become absorbed into the "mysterie" of the practice of guilds and their monopoly on "established products", to accrue to the state (David, 2008, p.18).

In the early 17th Century, the connection between the University and the informal contributions to 'science' was less distinct. The letters shared with Henry Oldenburg as a precursor to formation of the Royal Society were from any number of sources, in many cases independent of institutions of higher learning (Hall and Hall, 1965)[6]. Allen, Qin, and Lancaster (1994) propose the aggregation and publishing of academic material in the 17th Century was created and perpetuated by a "persuasive community" of academics and gentleman[7] natural philosophers. This was a group coming together through common interest to influence and inform each other, and potentially a wider audience.

Rusnock (1999) describes the sharing of letters through the Royal Society as the early formation of a science-led 'correspondence network' which created 'a larger Republic.' Oldenburg's story is also one of his role as a key 'node' in the correspondence network of the time – on occasion to his detriment (after Hall and Hall, 1965). This early network, which gathered and translated science from Europe and catalogued 'discoveries' of 'the new world', upon gaining sovereign privilege, similarly became independent of institutional intervention.

The role of 'scientist' as a gentleman's preferred profession, which might be embedded in an institution, also took time to establish. For example, Lord Charles pursued science as 'a side interest' while his son Henry Cavendish "… made a complete life in science" (Jungnickel and McCormmach, 2001, p 1-2).

The first prominent publication which records a university in the Philosophical Transactions which I could locate in the Royal Society archive, notes a letter from Sir Isaac Newton from Kings College, Cambridge University, in 1671.[5] The connection with science and the Crown is made evident in the institutional commissioning of scientists via the Royal Society. The first example of a report of an appointed Committee of 'scientists' to *examine some questions in Gunnery* was recorded in the Philosophical Transactions in 1743. Neither the contributors nor any link to a university are given here, but a later paper - occupied on a similar theme - on *the method for securing the powder magazines at Purfleet* is attributed to the auspicious work of Cavendish, Watson, Franklin, Robertson, and Wilson (1773). This notes the affiliation of Cavendish to Cambridge University. A similar collaborative report appears on the *method of adjusting the fixed points of thermometers* (Cavendish et al., 1777) where Henry Cavendish is also noted as a Professor at Cambridge University. At this point we start to see the State-Institution-Scientist network more formally established in the publication process.

The first formal publication which records a contribution from a discrete Research Centre that I could locate occurs in 1910 from S.B. Schryver, Chemist to the Research Institute of the Cancer Hospital. "Research Centre" first appears in 1957 with a paper affiliated with the Poultry Research Centre, Edinburgh and a paper from the Anti-Locust Research Centre, London is published in 1962. This reinforces the view that these new institutional structures to address specific challenges emerged as a 20th Century form.

The compilation of letters, once formatted and published for wider distribution as the Philosophical Transactions, institutionalised the publication of scientific material and continues to have a profound effect on the way science is measured and valued. However, Secord notes that during Mary Somerville's time in the early 19th Century the nascent scientific community in Europe "... did not necessarily place publication at the core of its activity, but depended on other forms of communication, including correspondence, conversation, and connoisseurship" (Secord, 2018, np). The active international scientist is also not a new phenomenon. Correspondence network maps generated for researchers in the 18th Century, such as d'Alembert's' correspondence from 1730-1790, demonstrates a

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[5] The archives of the Royal Society were digitised and put fully online in 2017, providing an opportunity to readily trace these early collaborations and connections.

similar breadth of international engagement to that of contemporary researchers (Passeron & Massot, 2012).

This brief history aims to provide a counter narrative of the 'organising of science' to that of the 'research institution.' That is, although typically seen as 'institutionalised', science often proceeds outside the immediate confines of the institution. In addition, the concept of the transaction of letters and multiple modes of communication seen in science, is regaining focus. The very concept of 'scientists talking' is seen as a key organising mode of importance to collaboration (Mohr and White, 2008; Nature 2018). This links to the consideration of science as a network and a growing interest in this as a model for complex systems. As noted by Barabasi "… if we want to understand a complex system, we first need to know how its components interact with each other" (Barabási, 2016, p. 45). I explore in the following section how this shift from simply characterising networks as topology to exploring interactions offers greater intersection with organisational studies.

2.4.3 Beyond the institution – the organisation of science in a global research system

One of the challenges in approaching this research is the emergence of apparent 'supernetworks' in science which appear to dwarf the institutions they potentially grow from (Newman, 2001; Albert and Barabási, 1999). This places the Research Centre in the frame for further quantitative studies based on bibliometrics and other data. However, as Barabási later reflects, it is not the visualisation or further quantification of the network outputs, but the next frontier which is important, "... which is to understand the dynamics of the processes that take place on the network" (Barabási, 2009, p.413).

By taking a network view, the Research Centre could be seen simply as a node from which relationships, interactions and outputs can be traced and counted. However, Rip suggests more dynamic potential for changes in research configurations in post-modern HEIs. He notes this to have potential "... for the re-contextualisation of science in society" (Rip, 2004, p.115). Wagner (2019) similarly asks whether the self-organisation evident in global science could have wider relevance for societal organisation.

This proposes a dynamic shift in the institutional space. Rip (2004) references the emergence of strategic research and its institutional location in the post 1980s as a reflection of a new fluidity with the emergence of Mode 2 science. Defined simply, this environment sees the division between science and society become more diffuse (Baber et al., 1995; Nowotny et al, 2001). However, as delivery of global research by HEIs becomes an increasingly complex endeavour, Rip suggests configurations to enable research

delivery must also undertake a process of recombinance and diversification. This includes enabling "… a greater overlap with 'centres of excellence'"" (Rip, 2011, p.450).

The postmillennial socio-technological environment, seen to have rapidly transitioned Western society from a 'knowledge economy' to a 'network society' (Castell, 2010), has had an inevitable effect on the institution.[6] Teichler (2006) proposes the interconnected nature of the knowledge society was already reshaping Higher Education into a system which, rather than following linear expansion and diversification, is undergoing reconfiguration through more flexible and cyclical models of change. Autio and Thomas (2014) similarly suggest the rapid diffusion of boundaries between entities engaged in global research and, potentially, the changing nature of research configurations, are acting to fit this ecosystem view.

These states suggest a role for Research Centres to serve as a location for 'institutional experimentation' during periods of dynamic change. Whatever the mechanism for change, Teichler (2006) proposes that the Higher Education Institution is moving and potentially co-evolving through phases of societal change rather than through undertaking any radical reconstitution.

While Research Centres are generally considered to be located 'within' HEIs, more recent examinations of research networks suggest scale-free network formation in some fields of science (Albert & Barabási, 2002), of which Research Centres are a part. However, this may not be a uniquely contemporary phenomena. The exponential growth in research publications in certain fields was noted in the 1960s and its apparent viral (network like) nature was also well recognised and attributed to social interactions; "...When members of a social system are communicating with one another, a kind of contagion effect occurs in which individuals who have adopted an innovation influence those who have not yet adapted it" (Crane, 1972).

This review of the literature suggests Research Centres and the HEI may have, and could continue, to interact in ways which serve the demands of a complex globalised society as Research Centres extend the potential for network interactions in relation to the HEI. Whatever the underpinning factors, the growth in the Global Research Network points

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[6] During this period the emergence of Web2.0 services developed specifically for research managers and the researcher community has become a prominent part of the Global Research System. These initiatives include: open search engines with a research focus, such as Google Scholar; national approaches to research data management, such as the Australian National Data Service (ANDS) – now the Australian Research Data Commons (ARDC); sophisticated data mining and visualisation capability for data sources of journal publishers, such as InCites; systematisation of research outputs as digitised objects (DOIs); the establishment of unique identifiers for researchers (OrcIDs); development of independent researcher online platforms, such as ResearchGate; the integration of research outputs with social media platforms, such as Altmetrics, and many similar information systems based developments, which have transformed both the research landscape for the institution and the individual researcher.

to the relevance of an approach which can make sense of both the institution and the network.

The following section looks more specifically at the case of the Australian Centre of Excellence. Firstly, to understand how best to approach a study of the CoE as a Janus object by considering a range of ontological views, and secondly to consider how the CoE itself might be currently understood through other studies.

2. 5   Bridging studies of the institution and the network

This chapter provides the background for the integrative review which forms one of the studies for this research which is explored in more detail in Chapter 5. The purpose of integrating this work with the empirical study is to appropriately apply both institutional and network perspectives to the empirical analysis. However, one challenge is to bring together apparently diverse fields to enable an account of both institutional and network environments.

In parallel with new applications of institutional theory to more complex contexts, network science emerged as a field in its own right in the millennial period. In three now highly cited papers relevant to this research, Duncan Watts and Steven Strogatz formally modelled the 'collective dynamics of small-world networks' (Watts and Strogatz,1998), Réka Albert and Albert-László Barabási demonstrated evidence of scale-free networks in social systems (Albert and Barabási, 1999) and Mark Newman explored both of these phenomena more closely in large global research systems (Newman, 2001).

While a shared interest in complexity should offer potential for institutional scholars to become engaged by new findings in network science, a bibliometric analysis suggests that, to date, any overlay between applications of institutional theory and network science appears limited (see Figure 3.1). However, the literature suggests potential to bring these together. Firstly, because reflections on neo-institutional theory suggest that the collective and network aspects of its original thesis were overlooked (DiMaggio, 1995) and secondly, because reflections in network science acknowledged their equivalence to earlier sociological studies (Watts, 2004).

This suggested potential to bridge neo-institutional theory and network science through sociological perspectives in common to both fields. I explore the potential to reconnect these fields in this section via a close reading of both DiMaggio and Powell's seminal work of 'The Iron Cage Revisited', alongside Watts reflections on the 'new' network science written in (Watt, 2004). Both articles provide important moments or 'turns' in taking stock of each field at their time. A side-by side reading of 'The Iron Cage Revisited' from a network perspective with the rich reflections by Watts, allows an understanding of shared origins within sociological studies. These connections are discussed in relation to guiding network considerations in further studies which consider institutional theory. A fuller discussion of the intersection between institutional theory and network science is provided in relation to an analysis of the findings in Chapter 6.

This approach also has relevance in establishing the suitability of a proposed model for the research design.

2.5.1 Casting the net for network perspectives in institutional theory

In November 2014 the editors of the Journal of Management Studies asked "Has Institutional Theory Lost its Way?" In this edition they present a point-counterpoint discussion on institutional theory, which is taken up by Greenwood, Hinings and Whetten (2014), and Meyer and Höllerer (2014). The former propose that studies should redirect institutional theory to focus on understanding 'how organisations work', while Meyer and Höllerer propose that a focus on organisational form alone will neglect new developments in the phenomena of 'organising'. The editors then set down the challenge for institutional theorists to "move their specific theory forward" (Journal of Management Studies, 2014, p. 1204-5).

The contest was initiated by work by Thornton, Ocasio and Loudsbury, (2012) who proposed the perpetuation of dualities, ranging from 'rational' socio-economics to 'mindless' cognition as explanations for societal structures, was institutional theory's fundamental limitation. Greenwood et al concurred, proposing the antidote to neo-institutionalism and its obsession with homogeneity, is to reset "… [an] organizational level of analysis, and to treat organizations as actors", through institutional logics (Greenwood et al, 2014, p.1207). This methodological approach, based on the work of Friedland and Alford (1991), was an effort to free institutional theory from being 'trapped in a dialectic' through the polarities of institutionalism and neo-institutionalism.

In contrast, Meyer and Höllerer propose a need to refocus the theoretical lens onto more complex environments noting "… institutional theory in particular, has remained relatively silent in regard to complex designs" (Meyer and Höllerer, 2014, p.1226). Davis and Marquis (2005) also noted this apparent gap, suggesting theorists had shifted their focus too far toward the 'problematised environment' of the multinational corporation as the 'dominant institution' of the late 20th Century.

The integrative review explores an apparent lack of intersection between institutional theory and network science. In particular, the integrative review aims to consider the potential to achieve an understanding of the institutional intersections with complex design as proposed by Meyer and Höllerer through a greater intersection with findings from network science. Although there have been efforts to address the complex nature of research in the post-modern HEI (Mohr & White, 2008) and interests in developing a greater oversight on the Global Research System (Mooney, Duraiappah, & Larigauderie, 2013), there is currently not a clear framework for considering the duality of the institutional and network environment in the context of the Global Research environment. However, Sjöstedt also suggests potential for reciprocity, noting that "… research on large, complex

systems can inform existing research on governance and institutional theory" (Sjöstedt, 2019, p.293).

Of interest too are similar challenges from those engaged in network science. As Barabási acknowledges, in noting the work of earlier social network theorists, such as Granovetter, "…to be sure we were aware of these networks before. Yet, only recently have we acquired the data and tools to probe their topology" (Barabási, 2009, p 413).

2.5.2   DiMaggio and Powell's line in the sand

In their seminal work, The Iron Cage Revisited: Isomorphism and Collective Rationality, Paul DiMaggio and Walter Powell declare that 'institutional modernity', as understood through the 20th Century, had run its course (DiMaggio and Powell, 1983). This 'line in the sand' set a challenge for organisational scholars to consider 'institutional life' in wholly new ways. However, the paper also provides a point of reference to identify network perspectives in institutional theory.

In addition to DiMaggio and Powell's work earning over 50,000 citations[7], their contribution to the field of organisational studies has been systematically reviewed by Greenwood and Meyer (2008) and extended by others, such as Greenwood and Hinings (1993) through their work on reconciling dualisms. Others have effectively codified, mapped or re-interpreted 'The Iron Cage Revisited' in detail, particularly in terms of its central thesis on isomorphism. Most notably W. Richard Scott, in his life span view of institutional theory's adolescence (Scott, 1987) to its coming of age (Scott, 2014), has codified neo-institutional theory to support its application to organisational studies. More recently Carvalho et al (2017) remapped the work in relation to innovation, and its contribution (or comparison) to institutional logics has, as noted above, been critiqued by Thornton, Ocasio and Loudsbury (2012).

Based on subsequent reflections by DiMaggio (1995), as well as reviews by others of this radical 'new institutional theory', I want to reconsider this important work. Here I aim to better understand whether network concepts present in 'The Iron Cage Revisited' have become disengaged from the application of institutional theory and, if so, why. In focusing on the sources and influences for DiMaggio and Powell's key ideas which align with network

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[7] According to the publication site JSTOR DiMaggio and Powell's 1983 paper had received 51,153 citations by February 2021

concepts, the aim is also to trace the ways more recent authors apply institutional theory which may have taken up – or neglected – these network perspectives[8].

DiMaggio and Powell acknowledge the collaborative effort in the article's development. The input from John Meyer, Charles Perrow and Rosabeth Moss Kanter, whose work also appears substantively in the paper, suggest a rich collaboration. Certainly 'The Iron Cage Revisited' presents a breathtaking range of ideas. These encompass Marx's functionalism to Weber's rationalist order, through to drawing together a series of real-world cases which cover everything from policy impact on wayward girls to studies of Fortune500 Board members.

However, the authors also carefully signpost where they diverge from their mentors and near contemporaries: graciously noting Hannon and Freeman's points on selection as valid but adding adaptation to their ecological view; acknowledging March and Cohen's points on loose coupling creating variation (after Weick) but contesting that, when placed alongside "ceremonial practices" they find "…greater homogeneity and less variation and change" (DiMaggio and Powell, 1983, p.155).

From these points of divergence, signal their ambition for an ecological view of "institutional life" (DiMaggio and Powel, 1983, p.148). They see this holistic perspective is (to paraphrase), neither limited to Hannan and Freeman's population view of an organisational world driven by competition and survival, nor solely aligned with Laumann's view of networks of organisations which are simply interconnected. Rather, DiMaggio and Powell are interested in the "totality of actors", as both connected and structured. They then describe these groups of organisations which constitute institutional life as the "organisational field" (DiMaggio and Powell, 1983, p.148).

'The Iron Cage Revisited' doesn't directly use the term 'complex system.' However, there are clues that this is their field of interest. Firstly, the authors define the organisational field as their 'catch all' descriptor for all those agents engaged in inter-related organisational ventures. The authors also acknowledge Weber's example of "…a complex, rationalized system of contract law" which established a "common legal environment" (DiMaggio and Powell, 1983, p.150). They also point to the strange recursive, ecological nature of organisational behaviour based on Schelling's view, that "… organisations responding to their environment … consists of organisations responding to an environment of organisations' responses" (DiMaggio and Powell, 1983, p.149). However, they do reference Katz (1975), who was applying the concept of complex systems in ways and

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[8] In order to review the substantive contributions in more detail a basic coding of all the 86 sources used in the paper was applied to map predecessors and sources for 'The Iron Cage Revisited.' This was done systematically to identify network terms and their related citations, but also to assist with a more methodical reading of the text.

contexts which closely aligns with the contemporary interests of DiMaggio and Powell (such as the US school system).

So, what is there of interest to frame studies of networks with some grip on the institutional life? DiMaggio and Powell look at multiple layers in a way that is of interest to network science, from the macro societal view through to the micro view of practices. At their most radical they upset two schools of sociology. Firstly, by proposing Weber's exposition on bureaucracy was fully complete by the late 20th Century in both the State and the Corporation. Secondly and secondly by contesting that Marx's view that institutional change is a process of pure accumulation as part of the social system, no longer held.

Rather than exercising control, DiMaggio and Powell present evidence to suggest elites are just as clueless as everyone else about how things work. They allege any understanding of the 'smooth social order held together by institutions' was, on closer examination based on findings from, "… the confused and contentious bumblers that populate the pages of organizational case studies" (DiMaggio and Powell, 1983, p. 156).

In unpacking the network elements in the Iron Cage Revisited in more detail, it is difficult not to defer to the sets of hypotheses and the classifications of isomorphism which lead the reader through the work. Their central thesis on isomorphism in organisations takes prominence, drawing together Hawley's ecological definition of isomorphism, Gidden's structuration theory and Thompson's descriptions of organisational interdependence. DiMaggio and Powell draw particularly on substantive longitudinal historic case studies as their evidence, albeit with a potentially narrow focus on the US context. Their evidence comes from; the school system (after Katz, 1975), municipal reform (after Tolbert and Zucker, 1981 and Knoke, 1982) and the study by Coser, Kadushin and Powell (1982) on the change over time of text-book publishing. Here, they consider historical studies of whole industries or government sectors, noting the observation of aggregation overtime as an industry or new set of rules establish.

DiMaggio and Powell's eclectic approach perhaps contributed to institutional theory being accused of trying to be the 'theory of everything' (Scott, 2014, citing Palmer et al, p. 139) – from practices to policy, from the macro-institutions of hospitals and schools to corporations through to the less formal or even the 'non-economic' socially recognised 'institutional values' of the Arts. While this eclecticism provides broad access for institutional researchers, it also can make it difficult to focus clearly through a particular theoretical lens. Easier perhaps to revert to the formulaic three types of isomorphism and test for their presence?

So where exactly is collective rationality in 'The Iron Cage Revisited?' DiMaggio and Powell's interest extends to not-for-profit and community organisations for examples. Here they look to ways these groups frame their 'life' in relation to donors, governments and other dominant institutional actors. To paraphrase, the examples given suggest that:

> '… the collectivist organisation has to find some way to deal with the more hierarchical institutional world (after Rothschild-Whitt, 1979); the free school has to nominally have 'a principal' (after Swidler, 1979); the commune has to find 'a way of interacting with the outside world' (after Kanter, 1972); the neighbourhood committed to participatory democracy "are driven to hierarchy … in order to interact with hierarchical donors" (after Milofsky, 1981).'
>
> (all from DiMaggio and Powell, 1983, p.151)

Despite Powell being mentored by Mark Granovetter, the paper only briefly mentions Granovetter's ground breaking work on social network analysis. However, they do point to more phenomenological aspects which might be important to linking the institution and the network through the field of mathematical sociology (see Boorman and Levitt, 1980) by noting the role of uncertainty. Considered at the conceptual level and, what we might refer to as network behaviour, is noted by DiMaggio and Powell as dynamics and disequilibrium in describing a 'tipping point' which can result in rapid organisational dominance (after Granovetter, 1978).

These provide some insight into the network perspectives DiMaggio and Powell were exploring which might underpin but were, perhaps, not made more explicit in their work. Nevertheless, these brief references can be read today with interest in relation to the rise of the global research system and the rapid development of the post millennial tech giants (for example) which have harnessed the internet to grow through an apparent phenomenological nature over a very brief period.

While this aspect of network complexity noted by DiMaggio and Powell appears to be less directly explored by further studies, their micro view of practices within organisations, emphasising examples of diffusion and adoption, are more prominent. DiMaggio and Powell also pay attention to actor relationships both at the level of the organisational collective, from the increasingly embedded roles of 'the professions' through to the 'homosexual[9] reproduction' of the management class (after Kanter, 1977) in established organisations.

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[9] The term 'parthenogenic' or 'clonal' reproduction may now be more appropriate here.

While a systematic reading only reaffirms DiMaggio and Powell's isomorphism as the prominent aspect of their thesis, which reasonably accounts for organisational researchers' engagement with their 'three types of isomorphism', their emphasis on an ecological view is also made relatively strongly and this aligns well with complex systems approaches. However, DiMaggio and Powell also directly consider the case of 'the institution meeting the network' where they suggest that informal organisational types follow a subtle form of "coercive isomorphism" in order to interact with a more dominant institutional environment. However, these examples could also be interpreted as being more to do with 'ways of interacting' rather than cases of informal organisation inevitably becoming isomorphic in relation to the institution.

While descriptions of 'organisational field' and 'organisational groups' could be seen as equivalents for 'complex systems' and 'clusters', it may be that DiMaggio and Powell specifically avoided these types of terms in favour of their own definitions. One limitation for researchers tapping the network concepts in the Iron Cage Revisited may be the way DiMaggio and Powell provide their own definitions of network characteristics, albeit in footnotes, on *connectedness* and *structural equivalence*. Similarly, their definition of the 'informal organisational-level ties' is placed in the footnote. The noted network-like terms; *clique*, *role* and *block* which can be translated to today's network science terms in ways that could better support reference to their network concepts. It may be that this 'lost in translation' also feels like a gap when, in fact, there is simply a terminology to be addressed.

In the next section I look at the later but equivalent retrospective work by Watts (2004). Watts provides a terminology bridge by linking a number of network terms which have been applied in sociological studies to their equivalents in more mathematical fields. By better linking DiMaggio and Powell's conceptual ideas of 'the totality of relevant actors' and outline definitions with Watt's analysis below, I aim to bring together a way for network science to be more effectively referenced in studies drawing on institutional theory.

2.5.3   Watts' Taxonomy – A catalogue of networks

In 2004 Duncan Watts undertook a comprehensive stocktake of key findings in contemporary network studies. This effort reconnected and, in some cases, 'recovered' a lineage to earlier work in sociology. Watts first notes that the 'new science' of networks heralded by Barabási (2002) is really '… not so new' and sets about chronicling and categorising a genealogy of network studies with reference to their predecessors (Watts, 2004). In looking at the millennial birth and precocious growth of 'network science', Watts describes how the accessibility to large data sources and high-level computing enabled more sophisticated networks models to be explored across a wide range of fields and contexts of interest.

In laying out the definitions of network types, Watts 'joins the dots' back to foundational studies in mathematics, physics, ecology and epidemiology (notably disease transmission). He also notes this rush to model networks based on 'Big Data' did not necessarily stop to acknowledge precedence in real-world sociological studies. In particular, Watts highlights the foundational work of Milgram's social network letter experiments, which Granovetter applied to demonstrate his case for 'strength of weak ties.' Watts notes that what was described by the Watts-Strogatz small-world model, in particular their 'small-world shortcuts', were equivalent to Granovetter's 'bridges.' Watts also picks up Merton's exploration of the 'Matthew Effect', which is later relabelled in network science as the phenomenon of 'preferential attachment.'

Although Watts doesn't attempt a formal taxonomy in this paper, he does note that his work on small-world networks (Watts and Strogatz, 1998) identifies "… a universal class of networks; that is, a family of networks that share certain aggregate properties regardless of many of their individual details" (Watts, 2004, p.246). While Watts groups networks in relation to sociological as well as other applied studies, he uses the term 'class' variously to categorise groups within networks – eg 'classes of susceptible or infected individuals', or to set out network characteristics – eg 'classes of degree distribution' and 'classes of nodes', rather than attempting any more rigorous taxonomy. However, I have been able to use Watt's three main 'network groupings' and links to their predecessors to provide an outline taxonomy: the Watts-Strogatz 'small-world class'; the 'random class', which considers (for modelling purposes) of 'hybrid networks' in relation to organisational forms, and, finally, the special class of Albert-Barabási's 'scale-free networks.' This mapping, based on Watts' groupings and descriptions, is shown in Figure 2.8 below.

In addition to noting the distinctions between these networks as configuration types, Watts provides valuable comparators. Of importance is that these suggest

differences not only in structure but in their modelling the resultant network behaviour. For example, Watts describes the distinction between random models of disease spread (where individuals are assumed to mix randomly) and pandemics which take on scale-free characteristics, with models of collective decision making (social contagion) which exhibit different threshold effects.

Although Watts concludes that a more interdisciplinary approach is required in network science, he also notes some limitations with its initial well heralded findings. He notes that although new 'network types' and new network phenomena are rapidly being catalogued, particularly by Newman, Kleinberg and others, a disconnect in models and real-world networks persists. Here he notes "… the Watts-Strogatz model [of small world networks] suffers from some serious problems that render it unsuitable as a model of social networks" (Watts, 2004, p. 247). Although this feels self-deprecating, Watts also notes the development of the small-world network model, as well as hybrid models, which approach equivalence to those of organisational studies.

These models move beyond reconnecting links within a (contained) one-dimensional lattice to look at multi-layered networks, such as Kleinberg's navigation model which led to the development of the 'generalised small-world network.' In Kleinberg's model, information is 'searchable' through random links beyond the small-world which links back to a 'lattice substrate.' A further iteration by Newman models a 'generalised bipartite networks' which takes a more dynamic view of layers of network types. This is well explored in relation to organisational studies of social networks – the typical example being members of boards sharing connections via multiple organisations.

An important feature of these network layers is that they allow for searchability while retaining elements of neighbourhood (small-world) connectivity for resources and information. These studies all draw on Milgram's letter experiments from the 1960s which explore the six degrees of separation phenomenon. These demonstrate that random contacts beyond an individual's immediate 'neighbourhood' extend networks, but that these links are also searchable by others with very limited additional information.

Watts' focus here is on network configurations, but he also notes particular variations in network behaviour when comparing 'natural networks' versus social networks. In the former case - which include classical disease transmission models which assume random populations - associations, relationships and proximity are understood to determine the likelihood that an infectious agent will be transmitted from one susceptible individual to another. In the latter case social interactions, which lead to network formation, are also "…thought to influence individual (micro) and collective (macro) behaviour as well as the relationship between the two" (Watts, 2004, p.256). However, the threshold effect in social

contagion (also modelled by Granovetter and Soong, 1988 in relation to thresholds of diversity) reveals different characteristics.

Watts applies a caveat to his interpretation of structure based on a physicists view of a low-dimensional grid, noting that "… clearly, social networks are not simply built on a lattice substrate" (Watts, 2004, p.244). However, there is some hint of interest in how this 'more locally ordered form' of network could be seen as equivalent to concepts of Weberian formal structure in institutional theory. Watts comes close to approaching DiMaggio and Powell, particularly where he acknowledges Granovetter and outlines the work by Harrison (Harry) White. Watts also refers to the role of the 'actor' in the sociological sense and notes the institutional and organisational settings of network studies which demonstrate a "… larger pattern of relationships" (Watts, 2004, p.256). This aligns with DiMaggio and Powell's concept of the 'organisational field.' Watts also cites studies describing 'hybrid networks.' These include valuable links to institutional theory, including: concepts of 'network motifs' (Milos et al, 2002); 'ultrarobust networks' (Dodds, Watts and Sabel's (2003); and 'community network structures' (Girvan and Newman, 2003).

These are reworkings and models which all have direct relevance to organisational studies. In particular, the reworking of small world and random networks by Dodd, Watts and Sabel (2003) (also supported by Harry White), directly consider organisational networks by drawing on archetypes of organisation of manufacturing described by Lawrence and Lorsch (1967). By modelling these organisational 'types' from the ground up by adding new nodes and links, Dodd, Watts and Sabel provide views of both multiscale structure and dynamic behaviour. Lawrence and Lorsch (1967) were acknowledged for exploring 'integration' via the "… different degrees of diversification of styles and structures", while also being critiqued for limiting their focus to organisational types that might not allow their findings to apply more universally (Baker, 1969, p.253).

Nevertheless, Lawrence and Lorsch's now classical cases lend themselves to new approaches to model differentiation in complex organisations. In exploring this set of organisational types as networks, Dodds et al specifically consider how structure impacts information exchange. They consider network robustness as a product of both "… congestion robustness (the capacity to protect individual nodes from congestion) and connectivity robustness (the capacity to remain connected even when individual failures do occur)" (Dodds et al, 2003, p. 12519). These additional perspectives are of interest in considering how they might be influenced or impacted for networks within an institutional environment.

Watts later notes "… organizational networks must exhibit non-hierarchical ties that extend across all scales of the underlying hierarchy, and [these] quantitative results align

with sociological qualitative work of Granovetter (1985)" (Watts, 2004, p. 264). These more direct considerations of models based on network science, but with their foundation in sociology, provide a useful foundation from which to explore the institution and the network. The additional considerations of 'robustness' relates closely to more theoretical concepts, such as organisational persistence.

Figure 2.6   Watt's taxonomy and timeline of network models related to network science (after Watts, 2004)
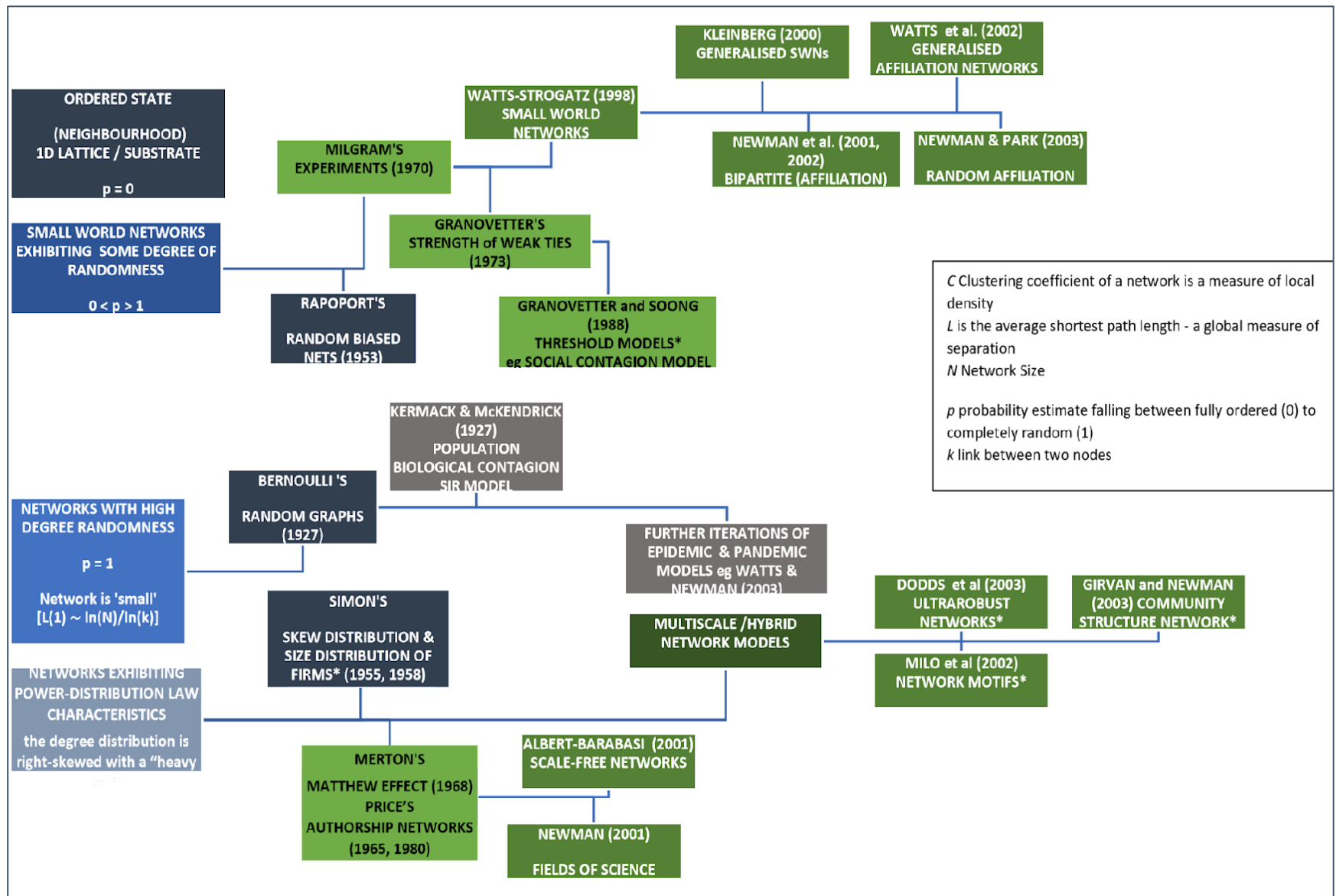
2.6　　　The National Research Centre as a Janus object

The literature review highlights ways the Research Centre acts as a site of both inter- and intra-organisational collaboration. While Research Centres might be considered to be wholly embedded in the HEI, which is then embedded in the macro-institution of the State, at least in the case of public universities, this is not the case for Centres of Excellence. This section considers the case of National Research Centres as a wider programme which may engage multiple institutions or inter-institutional engagement to provide context for the review of literature. This section focuses on an ontological exploration, firstly to support the establishment of the case of the CoE as a Janus object for the purpose of the empirical study. Secondly, the review aims to support the interpretation and analysis of findings.

The 'Janus object' also tackles the dialectic of institutional theory, where there is potential to "…see two or more antitheses conceived simultaneously, either as existing side by side, or as equally operative, valid or true" Cameron, 1984, p.136 after Rothenburg). Janus perspectives have similarly been considered at the level of 'science as knowledge.' Here one view 'sees' what is known, and the other looks out to what is not yet known (Latour, 2001, p.7). Cameron also considers a Janusian approach at the institutional level. In order to adapt, he suggests HEI managers and administrators need to adopt "… Janusian thinking and develop Janusian institutions" (Cameron, 1984, p.134).

The concept of indirect observation in the case of using a Research Centre as a Janus object also aims to overcome a challenge in a direct study of institutions. In contrast to Cameron's proposition, as Mohr and White note, there is an "…inherent limitation of using the institution itself as an analytic focus" (Mohr and White, 2008, p.507). This is based on Giddens' methodological *epoché.* To simplify, Giddens' proposition is that, by their nature, institutional structure and actors inter-relate so closely that our ability to affirm or deny any particular observation of one without being confounded by the other is not possible (Giddens, 1979). By assuming something of the uncertainty principle[10] at play, we can hope to 'follow the narratives' of those based in the CoEs to build up a picture of the institution and the network. This view in particular follows Searle's view of the ontological role of 'the observer' (Searle, 2005).

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[10] Heisenberg's Uncertainty Principle - How does knowing which slit the electron passed through change the pattern? The answer is fundamentally important—*measurement affects the system being observed*. Information can be lost, and in some cases, it is impossible to measure two physical quantities simultaneously to exact precision. For example, you can measure the position of a moving electron by scattering light or other electrons from it. Those probes have momentum themselves, and by scattering from the electron, they change its momentum *in a manner that loses information*. There is a limit to absolute knowledge, even in principle. From Probability: The Heisenberg Uncertainty Principle | Physics (lumenlearning.com)

Other conceptual views of 'a Janus' are relevant to the research approach. Lorenz, Clampit and Ramsey (2018) describe 'distance as a Janus' noting the inter-relationships between 'home' and 'host' organisations in different countries. This has some relevance to the CoE study where CoEs are nominally administered by a lead institution but interconnected by multiple 'node' institutions across Australia.

2.6.1 Ontological perspectives – why 'what is a Research Centre' is important

This section provides an overview of the ontological considerations in supporting the research design. As noted earlier, Research Centres of the 20th Century are seen to conform to recognisable taxonomic groupings. However, more recent proliferation of organising forms in relation to the institution elude a clear ontology. This understanding is important in order to address Meyer and Höllerer's (2014) proposition for considering pluriform organisations.

Why does a consideration of 'what is a Research Centre' matter? In the case of the CoE, the Janus object is being considered in relation to its position to observe both the institution and the network environment. Secondly the CoEs, although starting from a similar base as described above, may emerge in different ways. Also, as a network-like organisation, the CoE may evolve self-organisation in a particular way. These considerations require a basis from which the empirical findings can be best interpreted.

Based on the literature I have summarised a range of possible ontological views in Table 2.2. In addition to perspectives from institutional theory, there are three additional views of merit. Firstly, the ontological view of the Research Centre as 'an observer entity' (after Searle, 2005) and, secondly, based on their asymmetrical and transient relationship, as a relational 'spacetime event' based on Whitehead's ontology (McHenry, 1997). In the unique case of science, I also trace the historic relationship between science and the institution to note that the 'ontological commitment' to a field (Potter, 2010) could be the prominent determinant of the typology of a network-like organisation in science.

There are a number of existing ontologies to consider the CoE as self-evident entities. We can revisit existing Research Centre taxonomies and compare them to these sets of typologies. We can also look at the CoE in terms of organisational scale; ie - macro (environmental context), meso (structural, institutional levels) to micro (internal function, individual roles and processes), after Scott (2010). Existing organisational archetypes, such as Mintzberg's configurations (Mintzberg, 1992) or through consideration of Stafford Beer's organisational complexity, where the organised entity relates to its environment (Beer, 1984) are also possibilities.

Krijnen also questions this challenge: "... is [an] organization to be regarded as an objective and structured entity or as a temporarily stabilized cluster, loosely held together by relational networks of meaning?" (Krijnen, 2015, pp. 153-154). Dorothy Smith similarly notes the undecided nature of any organizational ontology. Her critique is that we are left with a type of "... blobontology – that is, for every discursive object named, [such as 'institution'], there is assumed to be something out there of which we can speak without worrying about **how** it exists" (Smith, 2007, p. 166, my emphasis). In the case of large institutions, such as universities, Smith (2001) also notes (to paraphrase) that, the closer you approach the institution, which is seen at large as a tangible entity, the more 'the entity' itself evaporates into a subset of processes.

However, here I want to briefly explore why considerations of emergence and a dynamic view, in which both institutional and network-like elements are at play, are an important aspect for an ontological view of the CoE in context. As an institutional object, the CoE would more readily be explained as part of nested or embedded relationships (Enders, 2004). In resetting the ontology of 'organization', Krijen (2015) notes the overwhelming acceptance of the pragmatic or materialist perspective of social purpose. That is, that the phenomenon of the modern organisation as a rational system arises "... to achieve (social) goals beyond the reach of the individual" (as cited in Scott (2003), Krijen, 2015, p. 151).

However, a duality in organizational studies arises if organizations are viewed as either entities or processes. That is, the view that social organisations as "...collectives of people pursuing multiple interests" are not reducible in the same way as natural systems and processes (Krijen, 2015, p.163). The literature suggests that a CoE can be classed in organisational terms based on how it is socially constructed as a form of "... collective intentionality" (after Searle, 2005).

In institutional terms, how the CoE is constituted and by what rules the CoE is enacted can also provide an ontological view (Hindriks, 2007). As shown by the range of potential taxonomies, from historic examples and considerations through real world case studies outlined in Section 2.3, there has been a tendency to view Research Centres through the purposeful role of institutions. In the literature analysis we also see the rise of consideration of other organisational network-like entities, such as entrepreneurial start-ups and social enterprises, which may have more similarity to CoEs, if only because they follow a similarly precarious temporal life. Table 2.2 below shows an overview schema derived for considering ontological perspectives in which context of the CoE can be explored more widely.

Another characteristic from an institutionalist perspective is legitimacy and the symbolic status granted to institutions. For example, the legitimacy granted to the 'modern western research university' can be regarded through its nested role in the socioeconomic nation state. This extends to the particular symbolic roles of universities in the "… generation and transmission of ideology and the selection and formation of elites" (Enders, 2004, p.362). While the HEI which, as discussed in Section 2.3.1, generates a symbolic universe, the CoE may have much weaker potential to 'make itself visible' in such an institutional environment. Although the CoE similarly generates ideas, its potential to establish a symbolic 'life' in terms of institutional recognition is less apparent, particularly given its relatively brief lifespan – and this is looked at in more detail below.

Table 2.2   The CoE in context: an ontological view

Institutional Lens (Taxonomic characteristics of the institutional field)	Ontological perspectives used to consider the CoE in context		
	Institutionalist / Structuralist View	Space-Time / Population View (Neo-institutional View)	Field of Science (Network / Collective View)
Embeddedness (after Searle, 2005, Hodgson, 2007)	Strongly embedded in institutional environment eg as a 'national entity' (Enders, 2004)	Linked by coincident events relative to [perceived] established entity (after Whitehead, see McHenry 1997)	Emergent, associated with, but not embedded, in other institutions (Czarniawska, 2009; also Lepsius, 2017).
Status (Self-referencing)	Derived by 'making a place' in the established institutional environment (Etzkowitz, 2003)	Derived from persistence over time (Cameron and Whetten, 1983)	Derived from social interaction / emergent community of science (after Whitehead, see Desmet and Irvine, 2018)
Identity / Constitution (after Quine see McHenry, 1997; Smith 2003 and Hindricks, 2009)	Formed by an 'idea' but constituted by recursive processes (after Meyer, 1987; Barley & Tolbert, 1997) and by 'attaining visibility' (Czarniawska, 2009)	Derived from establishment relative to another entity (Cameron and Whetten, 1983)	Derived from discovery eg emergence of new fields of science (Smith, 2003, after Quine)
Legitimacy / Autonomy (after Zucker, 1997)	Granted by structural rules – eg state endowed licence, regulatory environment (Etzkowitz and Klemegor, 1998)	Derived from survival over time as a "legitimized social grouping." (DiMaggio and Powell, 1983) Legitimacy as a member of a population of multiple similar entities Carroll and Hannan (1991)	Derived from science community, recognition of expertise (Lepsius, 2017) or through "repertoire of objects of science to which community attaches legitimacy" (Smith, 2003 after Quine)

2.6.2   National Research Centres as relative spacetime events and populations

The 'existence' of a CoE fits one definition proposed by Searle of a 'social fact' as "…any fact that contains the collective intentionality of two or more individuals" (Hindriks, 2011, p.377). According to Searle, a corporation or a HEI, is an entity by virtue of outliving the collections of its members (Hindriks, 2009, p.263), However, the relatively short lifespan of the CoE appears to break with Searle's rule of a 'constituted entity, for CoEs are usually developed as 'members' join and then, typically, dissipate at the end of its lifespan.

One ontological view which aligns with transience, is Whitehead's process approach as an 'event' based on a spacetime perspective. Whitehead's ontology allows an explanation of social objects according to events, relationships and interactions as descriptors of objects, as well as a perspective that allows for "… transitive and asymmetrical relations" (McHenry, 1997 p. 6). Whitehead's ontology also allows for the *role of perception and experience* in constructing an object – "… the built-up experience of events and relationships which brings something into being" (McHenry, 1997, p.9). Giddens too considered the place of encounters (after Goffman) as a spacetime event of relevance to the structuration of society (Giddens, 1984

This accounts for how a less tangible and transient form, such as a CoE, may be viewed and understood. In the 'context' of a complex system, the CoE may also be considered an 'emergent' form. This contrasts with the context of the national research system, where the CoE may be seen as a socio-political object that is perceived as 'real' or, at least, a describable object by the experience of those engaged in its activities – even within a logical frame).

While the more transient nature of the CoE suggests Research Centres might also be considered in terms of an event rather than an entity in ontological terms, neo-institutionalism also accommodates this wider view. This applies by seeing institutions as not wholly bounded and constructed by rules, but as "… socially constructed *templates* for action, generated and maintained through ongoing interactions" (Barley and Tolbert, 1997, p. 94). In this way, the CoE could be classed as a nested *event* of the HEI.

Another ontological take on spacetime is that of duration. The Hegellian and Bergsonian concept of 'becoming' allows for the way 'things' change over time. Looking at these views Scott notes, "Hegel [proposes] a negative movement of determination", while Bergson's view is more "… open-ended, undetermined … and more fundamentally creative" (Scott, 2010, pp. 91). However, Bergson also suggests that "...as soon as [an]

organization loses positive, open-ended movement, it atrophies into a determined order" (Scott, 2010, pp. 92).

While this seemingly contradicts an institutionalist's view of 'institutions as order' and entropy as the converse state, these considerations are interesting in relation to the CoE. Within the context of the study there is an anticipation that CoEs themselves and the CoE Programme as a whole can be explored through examples of interactions representative of creative or 'open-ended movement' over those of institutionalisation.

2.6.3 The National Research Centre as evidence of collectives and the organisation of science

In his work on the emergence of the entrepreneurial university, Etzkowitz notes a view of science from the institutionalised perspective of economic development. Although he highlights that "… science has emerged as an alternative engine of economic growth to the classic triumvirate of land, labor and capital", in citing Freeman and Soete (1997), Etzkowitz also emphasises that "… science has remained outside the framework of economic models" (Etzkowitz, 2003 p.109).

However, Etzkowitz describes the organisation of science into Research Centres as 'quasifirms' and notes that the entrepreneurial expectations for such reconfigurations are often aligned to the language of the corporation (Etzkowitz, 2003). In generic terms Research Centres may be simply defined as: *a collective or grouping of researchers coming together for the purpose of pursuing a recognised challenge in common*. Etzkowitz and Kemelgor describe Research Centres as a mechanism which allows for the growth in the collectivisation of academic science, by establishing "… (an) organisational framework for the coordination and expansion of research" (Etzkowitz & Klemengor, 1998, p. 271).

A definition by Enders (1973) notes a prevailing view that the Research Centre originally emerged as a means to deconstruct and "work across" the established institutional departments. The ARC CoE Programme similarly acts to 'work across' institutional boundaries, but also to attain a level of 'critical mass' for national knowledge and technological development.

However, in ontological terms, science itself is also said to hold a "repertoire of types of objects … to which those engaged in the science are committed" (Smith citing Quine, 2013, p.157). Applying the field of science may mean it is more pertinent to view National Research Centres as ontologically and organisationally related to a community of scientists. Searle, similarly distinguishes the natural sciences as non-institutional in that the purpose to discover truth holds "… no status functions with deontic powers" (Searle, 2005,

p.19) and considers industrial bureaucracies are not on par with "… the institutions of science, religion and education … [which represent] … massive forms of human practices" (in Hindriks, 2009, p. 259). Mohr and White (2008) similarly note the 'ontological' logic or orientation for scientists is truth, which is a distinct logic from that of the institution. Another ontological commitment noted is the "… sustaining of the claim of autonomy against other 'value spheres'" (Lepsius, 2017 p. 52).

Figure 2.4 below shows a simplified interpretation of the partial role of the HEI in the Research System. The time and space markers here indicate the dynamic nature of this system as a whole. The overlays between 'the objects' of the HEI and the Research Centre aim to convey a need to consider the relationships as a dynamic environment. For example, the overlays indicate that, although inter-related, the HEI response to the sociopolitical environment and the CoE's experience of the environment may result in quite distinct views of 'the present'.

This broad, adequatist approach also allows for a consideration of the "objects / entities, properties, processes and relations" at different "parts and moments at the different scientific disciplines" (Smith, 2003, p.157) which aligns well with the empirical study of the CoE.

Figure 2.4 A dynamic view of the Research Centre within the Global Research System (after Whitehead)
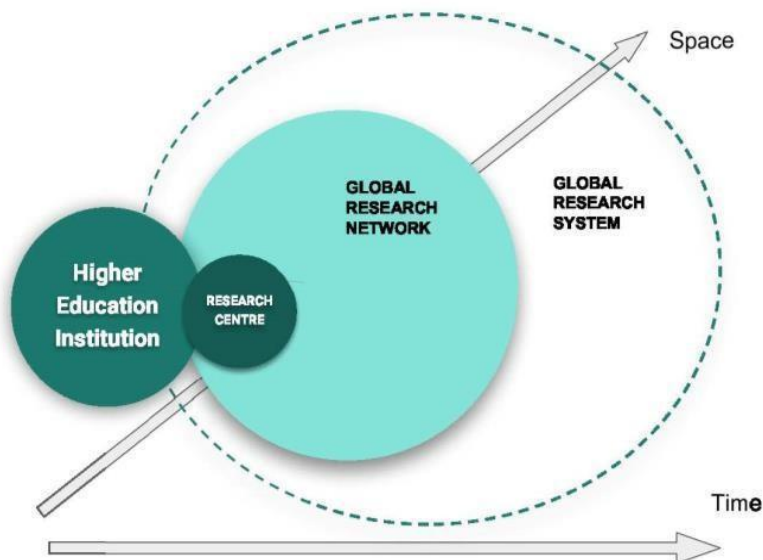
2.6.4　The Janus model

The apparent dualities of the institution and the network pose a challenge in framing the scope of the research. However, both institutional theory and network science are captured within an overall understanding of complex systems. This broad envelope of concepts, theoretical cases and models is encapsulated in a schema by Sayama (2015). The principle concepts of complex systems – self-organisation over time and emergence over scale – also provide a guiding model for considering the CoE as an emergent form. In addition, the schema allows for ontological perspectives of spacetime relevant to an understanding of dynamic systems.

Sayama's schema includes 'systems theory' which encompasses autopoiesis, cybernetics, sense-making and self-referencing as discussed earlier in relation to the nature of the HEI. In addition, the schema extends to studies of populations, including population dynamics, and allows for considerations of 'the collective' of relevance to considering the particular nature of the fields of science.

Figure 2.5 below shows a reworking of Sayama's schema as a means of organising the research design. This captures the two main focal theories; institutional and network theories, within Complex Systems. The concepts contained within Systems Theory and Collective Behaviour are included here as considerations which are closely aligned to institutional theory and network theory respectively. The model proposes that emergent organisations, such as the CoE, can be considered a Janus object in a complex system, to view both institutional and network environments.
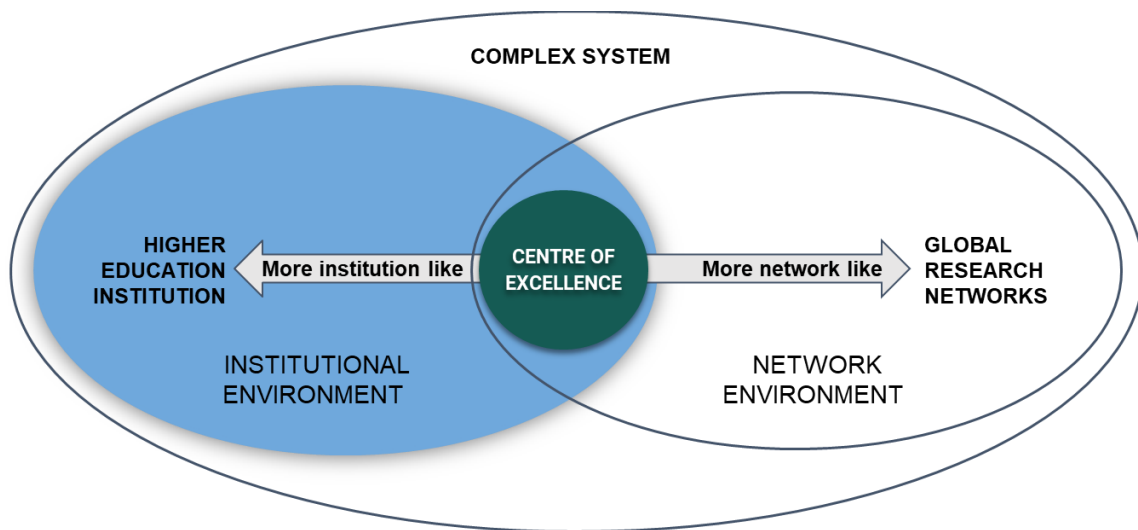
By understanding how those engaged in CoEs perceive both the institutional and network-like aspects of their environment, we can build a greater picture of how institutional theory might be of relevance to understanding network organisations in an institutional environment. These concepts of systems related descriptions aligning with institutional theory and collective behaviour theory relating to network theory are helpfully related through Complex Systems. This is important to this project as the Centres of Excellence role and interactions with HEIs and with the Global Research Network could potentially be understood more directly through these concepts.

By understanding how those engaged in National Research Centres perceive both the institutional and network-like aspects of the environment we can also build a richer picture of how institutional theory might be of relevance to understanding network like organisations in an institutional environment. These concepts of systems related descriptions which align with institutional theory and collective behaviour theory, are helpfully related through the Complex Systems schema. This is important to this research as the CoE interactions with HEIs and the Global Research Network could potentially be understood more directly through these concepts.

The primary sources drawn on to inform the network side of the model include seminal work by Watts and Strogatz (1998), Albert and Barabási (2002), Newman (2001), Barabási (2009) and the broader text on networks by Hexmoor (2015). As the model demonstrates there is a broad span across the possible environments the CoE might potentially 'observe' and interact in. In the next section I discuss potential to consider both the institution and the network in studies of complex systems.

2.6.5   Linking institutional theory and network science through a Janus lens

Of particular interest in relation to the study of the ARC's CoE Programme is DiMaggio and Powell's examples of less formal organisations aligning with more dominant / established entities. These examples all have relevance to the studies of CoEs presented here, for similarly existing in an apparently asymmetric relationship with much larger institutions and governing funding organisation. Is it possible that these examples of collective actions align with Ostrom's work on collective governance and game theory; are they looser forms of organisation imitating the institution or are they simply playing the institution's game?

These cases also align with Whitehead's philosophical take on transitive and asymmetric relationships and it may be that this aspect of connectedness is of most relevance to apply to a study of CoEs which appear to be both asymmetric and transient in their relationship to HEIs. Paradoxical findings, which are discussed later, also have relevance. For example, Newman's finding, that large bibliometric datasets in biological science which displayed a scale-free phenomenon also remarkably demonstrated a multitude of 'small worlds', affirmed that Milgram's original study also applies to the connectivity between biologists as predicted by (Newman, 2001).

The effort by Watts to build a more cohesive bridge between sociological studies and network science by looking for points of common lineage suggest potential to better bridge the field of network science and institutional theory. The shared contributions of Harrison (Harry) White and Mark Granovetter also note a direct lineage of ideas. In their review of the Iron Cage Revisited Greenwood and Meyer (2008) directly note the influence White had in supporting both DiMaggio and Powell in their studies of social networks.

However, Watts also notes limitations in the alignment between network science and sociological studies as twofold. Firstly, one of vocabulary and secondly, in the challenge in toggling between network structure and dynamics. Watts notes: "… unfortunately, although a rigorous and comprehensive vocabulary of network structure is clearly an important part of this larger problem—and thus recent progress in that respect is certainly helpful—the relationship between network structure and dynamical consequences is anything but straightforward" (Watts, 2004, p 256).

This lack of vocabulary on both the network and the institutional side suggested potential to map and look for areas of better alignment. I have made an overview of

comparative terms as part of the process of decoding the two bodies of literature. The output is given in Appendix VII.

A further challenge in bringing network science close to sociology is a divergence (or ignorance of) the closely related field of mathematical sociology. In his review on two new texts in the 'new' field of network science, mathematical sociologist Phillip Bonacich declares up front that "... the area of social networks is owned by sociology", noting that the 'new network science' players are "latecomers" (Bonacich, 2008, p.426). Nevertheless, in his book review of *The Structure and Dynamics of Networks* by Newman, Barabási and Watts (2006), Bonacich acknowledges that the "...models [of 'network science'] belong in our repertoire of theoretical tools even if the quest to find common emergent features in all social networks … prove to be quixotic" (Bonacich, 2008, p.427).

Helpfully, Bonacich also acknowledges some of the vocabulary gaps between social network studies and the terms emerging in network science. For example, he notes the use of 'clustering' is "... unfamiliar to sociologists" and notes there are new ways of considering centrality based on network science perspectives: "... along the way some new and unfamiliar measures are introduced: stress centrality, transversal sets centrality, random walk closeness centrality, random walk betweenness centrality, and many others" (Bonacich, 2008, p. 427).

Owen-Smith and Powell (2008) also revise their perspectives of networks in relation to institutional theory to note aspects of dynamics and emergence but do not extend to considering network science. However, they do identify apparent "… institutional cpntradictions" in the local and global effects in the case of biotechnical clusters and concluded that "… a network institutional theory sensitive to genesis and, particularly, change should have some way to account for when and why local action shifts larger fields" Owen-Smaith and Powell (2008, p. 615). These promising signs offered an indication for potential to bridge institutional theory with network science through their shared sociological roots. I look at this opportunity in more detail through the integrative review which is set out in Chapter 5.

Chapter 3   Approaching a study of the institution and the network

"… It is not surprising that the sociological analysis of the production of science… has been largely neglected since few sociological problems are so complex as that of understanding the social institutions that produce ideas."

(Crane, 1972)

3.1   Approaching the studies

As noted in the introduction, I bring together three studies which constitute the data collection for my research. The studies are: an integrative review of the fields of institutional theory and network science; an informative study of international research professionals on their interactions in institutional environments; and the main empirical study of the Australian Centres of Excellence (CoE) Programme. The sequence of data generation interlinks these studies as indicated earlier in Figure 1.2 and follows a concurrent transformative design, being "… guided primarily by the use of a theoretical design" (after Creswell in Robson and McCartan, 2016, p.177).

The literature review establishes an overall Janus model for the research design. This conceptually places the CoE as a Janus object within a complex system. The application of the model aims to allow theoretical, as well as perceptive, insights into the institutional and networked environments. To enable a wide view from the CoE, the informative study engaged Research Professionals via the International Network of Research Managers (INORMs) conference. The combined data output from the three studies provided a rich source of findings relating to the inter-relationship of network-like organisations of science in the institutional environment.

The research is predominantly exploratory and inductive. As noted in the literature review, a number of areas were identified which required further foundational understanding. These apparent 'gaps' explored in developing each study, were: a limited engagement with institutional theory and network science in applied studies of organisations; an emerging interest in the role of the globalised professions allied to science and the 'green site' of the Australian CoE Programme in terms of external empirical research.

Table 3.1 summarises the approaches taken with the three (3) studies. This includes informing perspectives and ontologies, the overall methodological view and the specific methods adopted for each study. Having established complex systems as a guiding theory, I adopt a methodology suggested by Nicolini (2009) of zooming in and zooming out while switching lenses. This aims to unify an approach in moving each of the three studies forward. As outlined in Chapter 2, I also apply an approach to *switching lenses* to the literature layer. This supports a view both the institution and the network through the reading.

In the case of considering practices, Nicolini suggests zooming in to recognise heterogeneity, then zooming out to "…describe ways in which practices are associated to form living assemblages … such as institutions" (Nicolini, 2009, p.1407). To accomplish this

in relation to the CoE study, I similarly use an approach to zoom in to consider the personal practices and interactions of the interviewee and then ask them to zoom out to look at the CoE as a whole in relation to the wider environment. Similarly, in the informative study of the research professionals, I use an approach of asking the participants to rearrange a set of interactions moving from 'my view' to 'their' perspectives. In this way I allow the participant to 'switch the lens' to gain new insights into the relative values of sets of interactions.

Before introducing the three studies in more detail in Section 3.4, I provide an overview of wider considerations in approaching the research. This section firstly considers how changes to perspectives of the organisation of science arrived through the advent of big data analytics in bibliometrics studies. Here I consider how the focus on bibliometrics impacted the HEI through Global University Rankings as a case where a methodology to understand research can result in unexpected institutional outcomes in its application.

I then consider some of historic challenges to conducting sociological studies of the conduct and practice of the empirical sciences. Translating these learnings to a study of the wider research system is considered in relation to other methodological approaches adopted in studies of similar national research systems. Here I briefly compare some of their value in informing this research and points at which I propose an opportunity to bring both institutional theory and network science into the frame of studies of such systems.

Table 3.1 Overview of research methodology, guiding theories and methods for three studies (after Creswell, 2009)

	Study 1 Integrative review of institutional theory and network science	Study 2 Informative study of research professionals allied to science	Study 3 Empirical study of the Australian Centres of Excellence Programme
Guiding points of enquiry	DiMaggio (1995); Watts (2004); Barabási (2009); Scott (2014)	Berman and Pitman (2010); Scott and Kerridge (2018)	Meyer and Höllerer (2014); Wagner (2019); Mohr and White (2008)
Guiding theories	Complex systems (after Sayama, 2015) (Darwin, 1859); (von Bertalanffy, 1968) (Glassman, 1973); (Maturana & Varela, 1991); (Weick, 1976, 1989)		
Theories in Focus	Institutional Theory (DiMaggio and Powell, 1983; Zucker, 1987) Social Network Theory (Granovetter, 1983)		
Guiding methodology	Zooming in and zooming out while switching lenses (Nicolini, 2009)		
Ontological perspectives	Shared philosophical and sociological perspectives (Milgram, 1967)	Role of 'the professions' *Formal organising* Weber *Informal organising - networks* DiMaggio and Powell (1983)	CoE as a Janus object/observer Searle (2005) Whitehead spacetime events (McHenry,1997) Science as story, as social construction Mohr & White (2008); Latour (2005)
Guiding Methods	Actor Network Theory (Latour, 2005) Integrative Literature Review (Torraco, 2005; Thornton, Loudsbury and Ocasio, 2012)	Symbolic interactionism (Cameron, 1984; Van den Hoonaard, 2013) Inhabited Institutionalism (Hallett et al, 2009) Focus Group Methods (Parker and Tritter, 2007)	Sociometrics (Crane,1969) Collective Action (Ostrom, 2000) Longitudinal studies of change (Pettigrew, 1990)
Analytical methods / analytical informants	Literature mapping (after Joanna Choukier, 2018) Close Reading (Riaza, 2016) Computer Aided Text Analysis (CATA) (Gaur and Kumar, 2018) Cluster Analysis Pearson similarity analysis	Cluster analysis – interactions data. Pilot Survey Statistical method (Meek, Ozgur and Dunning, 2007) Semantic Question Analysis (Harwell & Gatti, 2001; Wu, 2007) Immersion Tool test (Hidalgo, Smilkov & Jagdish, 2013)	Qualitative Interviews Thematic analysis (Creswell and Miller, 2000) Linguistic methods (Angouri, 2010) Qualitative data coding (Blair, 2015) Structuration – view of encounters data (Giddens, 1984) Network Pictures (Ramos and Ford, 2011) Network models eg Dodds, Watts and Sable (2003)

3.2 Establishing a vantage point for a view of the institution and the network

"… The primary contribution of institutes and centers on this campus has been to enable us, as a small university in a comparatively small state, to select certain specific areas of excellence in which to increase our scale of operation and attract larger numbers of faculty than could otherwise have been possible."

Ikenberry and Friedman (1972, p.34)

3.2.1 Research Design

The Janus model shown in Figure 2.7 provides a conceptual view but also serves to contain the focus for the research design. This assumes that the data captured from the CoE study has 'room to move' into either a more institution-like or more network-like perspective. In adopting a similarly flexible methodological overview (see Table 3.1), the research design aims to apply in studies of complex environments to both "… capture detail and to form a more complete picture of the whole" (Nicolini, 2009, p.1407).

As shown in Figure 1.1 the research design was informed by both sequential and iterative stages of data generation, in particular through a sequence of literature reviews and via a focus group with research professionals which informed the wider empirical study of the Centres of Excellence. This sequence of data generation and analysis follows a concurrent transformative design suggested by Creswell, as being "guided primarily by the use of a theoretical design" and with "qualitative and quantitative approaches used and integrated during interpretation" (after Cresswell in Robson, 2011 p. 178). In the case of the literature review, the theoretical design was informed by institutional theory in developing the semantic question set. In particular, the design aimed to prompt participants to respond to the apparent dualities inherent in institutional theory based on their experience in the institutional environment.

Although the literature review provides adequate cases of research centre studies, the lack of research which explores a neo-institutional perspective and seeks to understand the CoE as an organisational form, meant the approach taken was predominantly exploratory and qualitative. While the focus group responses to the semantic question set were analysed using quantitative methods, this was done to establish the validity of the questions rather than to specifically note any particular characteristics of the study group. Similarly the integrative literature review steps through a number of statistical methods, such as cluster analysis, to identify subsets of papers for further review. The analysis of the Centre of Excellence interviews also followed a quantitative approach to identify text frequency and predominant references across the transcript data.

However, interpreting the interview data through a deductive approach initially, for example, to consider whether statements could be sorted as 'more institution-like'; 'more network-like'; 'both institution and network like'; 'neither institution nor network like' (ie something else) proved limiting. The narratives presented a number of unexpected dynamics across in the CoE Programme - such as:

'... So [Uni2] was a very significant sort of second node to [Uni1] at the outset right, … but then (hah) - … - so we all worked very closely together, we still do in the context of the Centre, but – [Uni3] cleverly picked off the whole engineering chunk of … the branch of [Uni1's] effort, to the point … that [Uni3's] now a bigger partner than [Uni2] is' RL4.

As a categorical deductive approach was less helpful to account for the range of paradoxical statements and experiences, the research design then shifted to adopt a more interpretive approach. The change in design was supported in discussion with Professor Jo Angouri. Her work in linguistics notes the potential to "... better understand phenomena from triangulating findings (whether convergent or divergent)", as a more versatile approach (Angouri, 2010, p.35).

By changing approach, emergent themes of less expected statements were then considered from across the transcripts. The relative weight of those thematic statements - that is where similar statements emerged - were then used to consider a set of seven thematic statements for analysis via the lens of institutional theory.

A further triangulation of transcripts data was considered from a network perspective. This was based on participants' views of their perceived network (after Ramos & Ford, 2011). By adopting this method a form of 'network narrative' was developed to consider the particular narratives around the emergence and self organisation of the CoEs.

The following discussion also covers considerations made in developing the research design and approach. The considerations include alternate approaches taken in understanding the role of research centres from an institutional perspective. The challenges in approaching research on research is also considered. In particular, I consider a wider context of the rise in big data analysis in bibliometrics over sociological approaches to the study of science which have served to create challenges in gaining a deeper understanding of the institutional environment and its impact on the practice of science.

3.2.2 Why Research Centres? How others approach Research Centre studies

In seeking an appropriate methodological approach, Research Centres studies outlined in Chapter 2 noted equivalent structures established in HEIs, such as dedicated Organisational Research Units (ORUs) (Geiger, 1990). This review provides a theoretical and ontological perspective for the empirical study of the CoE.

However, If the ontological question asked was '*what* are Research Centres?', these empirical studies also asked: '*why* are Research Centres?' From the perspective of institutional theory, there is a question of *why* HEIs might seek to establish Research Centres as new structures.

Tolbert and Zucker note that "… creating new structures takes more resources than maintaining the old" (Tolbert & Zucker, 1999, p.180). They also note that creation of organisational structures constitutes costs for the organisation and therefore "… structures that are created must be believed to have some positive value for the organisation" (Tolbert & Zucker, 1999, p.180). Despite inconclusive benefits of new arrangements in institutions, the ongoing investment by the state and co-investment by private interests, could be logically expected to act as an endorsement for the value of generating new research configurations.

A foundational comparative study by Ikenberry & Friedman (1972) of HEI based Research Centres and Institutes in the US, highlights the differences in configurations and characteristics of new (non-departmental) research-producing units. Ikenberry and Friedman suggest Research Centres, when compared to the more *multi-functional* role of the department, are more constrained in the sense that they cannot offer courses or award degrees. However, they deliver benefits in being *multi-disciplinary* in function and because they *suggest* reputational value. Ikenberry and Friedman note university administrators were willing to approve new institutes on the basis that "…for some universities, institutes apparently held out the prospect for greatness" (Ikenberry and Friedman, 1972, p.188). This points to an example of reputational logic, which, as discussed in more detail below, can be an overriding motivation for the HEI.

As shown in Table 3.2 below, most equivalent studies reviewed took a socio-political perspective to consider the relative value of the Research Centre in relation to established forms of science delivery. However, more recent research, including that of Wagner (2018), which explore rich data processes in Africa's emerging research system, could offer further insight into aspects of self-organisation of science in relation to complex systems.

Researchers seeking to identify the tangible comparative benefits of HEI based Research Centres, have drawn on a range of methods. A comparison of paper co-authorship and citation rates from six Research Centres of economics with their equivalent departments in four Australian universities found no better outcomes than those produced by the traditionally configured HEI economics departments (Harris, 1989). Work by Bell in Canada, which analysed communication patterns by principal investigators using social network analysis, found no difference in Ontario's Centre of Excellence Programme than the level of HEI departmental engagement with industry (Bell, 1996).

Australia's Cooperative Research Centres (a sister programme to the CoEs) were recognised as returning a value as an innovation broker by "… provid[ing] a neutral space for research development" (Winch & Courtney, 2007). However, Winch and Courtney note that the social network analysis to demonstrate this case was, at that point, yet to be done. Other recent studies of Research Centres acknowledge the complexities and challenges within the institutional and globalised systems of research. A qualitative study by Borlaug and Gulbrandsen (2018) on the Centres of Excellence Programmes in Norway and Sweden considers the wider frame of institutional actors. Their work seeks to understand the potential competing institutional logics of 'excellence' and 'innovation' in relation to researcher orientation as well as seeking to better understand the internal aspects of research practices within an institutional logics framework.

Table 3.2.   Examples of approaches and focus of contemporary studies on Research Centres in HEIs (see opposite)

Geographic focus	Countries	Institutions	Author/s (citation)	Research Method	Social Perspective
National	USA	American HEIs	(Ikenberry & Friedman, 1972)	Comparative analysis: 125 Institute and Centre Director interviews and quantitative analysis. Develops a taxonomy of Centre types.	Socio-constructive – review of origin and configurations comparing Centres and Institutes in HEIs from 1960s
National	Australia	Australian HEIs	(Harris, 1989)	Comparative analysis - value of HEI Centres for Economics vs Departments via research citation rates	Political economy – considers relative return on investment for HEI Centres vs Departments
International / Regional	Numerous	North-South systems	(Greene, 1989)	Mainly political narrative – provides background to CoEs developed as North-South linkages e.g. UK-Africa-Caribbean. Socio-economic approach.	Political economy – considers the critical function of CoEs in knowledge economy of developing nations & relation with international funding.
National	USA	American HEIs	(Geiger, 1990)	Historic Narrative: Develops a potential taxonomy of evolution of Organised Research Units (ORUs) in the US.	Socio-political – covers the emergence of America as a dominant force in science. Builds on earlier work by RS Friedman & RC Friedman.
National	Canada (Ontario)	Ontario Centres of Excellence (Universities not named)	(Bell, 1996)	Network analysis – Agent communication theory. Empirical comparative analysis of effectiveness of CoEs vs HEI Departments. Socio-constructivist approach.	Socio-economic – looks for benefit of CoEs in industry engagement through communication frequency between CoE and Industry. Notes information flows may differ in CoE-industry partnerships.
National	USA	Numerous	(Etzkowitz & Kemelgor, 1998)	Historic narrative with discourse analysis based on 40 Centre Directors and staff interviews. Considers transition in public funding.	Socio-constructive approach. Political economy focus – looks at configuration and integration roles with government and industry. Also builds on earlier work by RS Friedman & RC Friedman.
International	Netherland; Malaysia and Indonesia	Rijksuniversiteit Groningen; Universiti Sains Malaysia; Institut Teknologi Bandung	(Beerkens, 2009)	Descriptive case studies – refers to Knowledge Society but describes Knowledge Economy. Refers briefly to loose coupling / decoupling between the global and the local	Socio-political Considers the local variants of CoEs in relation to their socio-political environments in Indonesia, Malaysia and the Netherlands.
National / State	Australia	University of Queensland	Dodgson and Staggs (2012)	Descriptive case studies of 4 research institutes. Qualitative, semi-structured interviews with 55 individuals engaged in the programme.	Political economy. University based institutes in the context of the knowledge economy and innovation systems. Triple Helix view – HE perspective.
Regional Europe	Slovenia; Hungary; Croatia	Eastern European, Universities of Ljubljana; Debrecen	(Zgaga, 2014)	Mainly political narrative. Describes the emergence of Centres in Higher Education research in the 1990 EU accession group. Focuses on HE Sector – public vs private institutions	Socio-political - Research Policy Describes the formation of centres as 'nuclei' to support undeveloped areas of research as a way of attaining critical mass.
National	Norway; Sweden	Centres of Excellence in Norway and Sweden	(Borlaug and Gulbrandsen (2018)	Comparative qualitative study – interviews with researchers. Applies institutional logics framework. (Study conducted 2009-10)	Socio-constructive. Impact of funding mechanisms on researcher practices. Considers tensions in the university-industry relations. Identification of ideal types of researchers.
National	Global Cases; Uganda	Global Research Programmes	Wagner (2018)	(Chapter 9) 'THICK' framework – interviews and workshops of cross-sector groups	Case study of Uganda's research system and overview of capacity demands. Considers the array of institutional actors.

3.3 The return of research on research

3.3.1 From sociometrics to bibliometrics and back again?

As Crane notes, 'getting to the heart' of the production of science is challenging. My research resonates with Crane's approach to further an understanding of the 'invisible college' through institutional relationships and interactions. Crane applied Coleman's sociometric connectedness to test whether "… social organisation exists in a research area" (Crane, 1969, p.336). Her conclusions closely iterate those of small world networks described in later models of collaboration in network science by Newman (2001). Crane's findings note "…each member is aware of some but not all other members" and "…while something of a social circle may develop in a research area, it seems unlikely that it would exist at all times in all research areas" (Crane, 1969, p.348).

Mathematical sociology was a well explored method in the 1960s. Studies of social networks were considered to be founded in its modern form by Jacob Moreno who assigned the term 'sociometry' (Borgatti and Ofem, 2012). Crane's 'sociometric' findings extended earlier studies, such as those by Price (1965), who identified 'cliques' in science. Crane's work identified the phenomenon of the rapid expansion in new fields of research, albeit at a time when researcher groups and research outputs were at a more comprehensible scale. As a forerunner to later studies in large bibliometric analysis, Price (1965), also recognised that outputs of science formed a proxy for researcher interactions by recording co-publication data.

However, as quantitative analysis of the artefacts of science emerged, it appears the sociological proximity to scientists waned. As late as 2005, Latour writes that the 'sociology of science' is a "…tiny subfield of science studies" (Latour, 2005, p.88). Crane's compiled studies of the interactions of scientists were met by, at best, damp praise: "…nothing in [Crane's] volume convinces me that we already know enough about the sociology of science—even in the limited way in which she has defined it" (Kaplan, 1973). As I discuss in Section 3.3, Latour's detailed observations of the practice of science was met with even stronger disdain.

Perhaps as a consequence, closer observations of science networks were 'lost' to some extent. However, the increased accessibility to the outputs of research publications also no doubt played a role. The perfect alignment of accessible publications data and computing allowed for a range of researchers, beyond the custodians of information

science, to tackle the world of research 'bibliometrics.' From Price's early exemplar of bibliometric studies, which considered the co-authorship of around 30 papers in physics, the work by Albert and Barabási (2002) was able to analyse science networks based on co-publications from seven (7) global databases. At this point mathematicians and physicists were becoming somewhat engaged in studying themselves. Despite this large volume of data, the study affirmed a finding made by Crane from a far smaller sample size, that some fields of science appeared to continue to grow, rather than wane over time (Crane, 1972).

This shift, in considering bibliometrics as a primary indicator of research impact, coincided with a rise in Web2.0 tools. Science output could now also be linked to more immediate measures of public and media engagement, rather than waiting for citations to indicate their potential value. Priem coined the term 'altmetrics' (suitably in a tweet, as #altmetrics) - to represent alternative metrics for 'counting' scholarly impact, based on engagement via the internet (Haustein, Bowman and Costas, 2016, p.372). Priem notes how the web also allowed a view of the invisible college at work "… the Web era is exposing the delicate tracework of ideas beneath the formal structures of the academy" (Priem, 2014, p.438). In particular, altmetrics is considered to have potential for richer approaches on how 'research excellence' is recognised (see Adams, McVeigh, Pendlebury and Szomszor, 2019).

While the work by Albert and Barabási (1999) identified the phenomenon of global science behaving as a true 'scale-free' network, over time Barabási recognised the limitations in simply producing models based on large volumes of bibliometrics. On reflection, Barabási (2009) notes a growing engagement in the field of network science to 'tap the topology of networks' and to 'understand interactions of the network'. In this way Barabási suggests a return to a form of richer sociometric analysis. As discussed later in the analysis of this research, Newman also followed his work on bibliometrics as 'big data' to consider more bespoke networks through interdisciplinary approaches which aligned with sociometric research (Lusseau and Newman, 2004).

Although there may be potential to consider the CoEs through evidence of their outputs, I took a more sociometric approach to the empirical study of the CoE (after Crane, 1969). This also aligns with a number of more recent studies which have also made a return to speaking directly to scientists. The value of this approach was affirmed by a reassuring comment by one senior participant in the CoE study, who noted '… no-one has ever asked me what I do.' However, rather than looking purely at researcher-researcher interactions, the methods employed also aimed to gain an overview of the CoE and its interaction in the institutional and networked environments.

3.2.2   Going beyond bibliometrics?

Institutional engagement in metrics has been tempered by more recent discussions on an overreliance on metrics. In the context of global research, there is a renewed academic interest in looking at 'research on research' methods. Crane's suggestion of a 'theory of culture', noting areas of similarity across different science groups (Crane, 1972), is also finding renewed resonance in the context of 21st Century science (Royal Society, 2018). As noted earlier, Wagner's view that the self-organisation of science could have wider relevance, is also an area of future prospect for research on research studies (Wagner, 2019).

Bibliometrics data have been widely applied to benchmark research quality by policy makers and executives in Higher Education alike. However, bibliometrics based on citations alone is increasingly viewed as an imperfect instrument in understanding effective collaborative research efforts (Cronin and Sugimoto, 2014). The foundation of the Research on Research Institute (RoRI) in the UK in 2019 is an example of a growing interest to support methods for future decision making and provide better outputs for the public.[11] This growing need to better understand the internal factors which enable research development suggest sociometric measures, which also consider research culture and institutional environment, could have a value in future research metrics.

However, information scientists note how bibliometric creations became a 'runaway science' - skipping beyond the hold of specialist curation. In this process they note problems with citation gaming (Sugimoto and Cronin, 2012; Adams, 2014) and gender bias (Cronin and Sugimoto, 2013). Those engaged in the field of understanding research also see metrics falling short of 'telling the story of science' in a meaningful way. Harrison White, also a sociometrician, reasserts this need to understand the network of science and the value scientists gain through interactions and story-telling (Mohr and White, 2008).

Although bibliometrics have been used more recently to highlight issues, such as gender representation in science (Elsevier, 2020), efforts to refine research metrics also risk excessive emphasis on return on investment and proxies for institutional reputational aims. Policy instruments, such as the UK's Research Excellence Framework (REF) and Australia's Excellence in Research Australia (ERA) programmes consider bibliometrics as a strong indicator of research achievement (Martin-Sardesai et al, 2017). In particular, the introduction of the ERA initiative was targeted to achieve an institutional level impact "… linking of elements of government funding to research performance incentivizes a strategic

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[11] Based on Research on Research Institute site http://researchonresearch.org/about November 2020

and operational response by Australian universities to improve the quality (and quantity) of research" (Martin-Sardesi et al, 2017, p.400).

While national analyses have typically surveyed the macro-environment of science with its broad statistics - total number of papers published/year etc - there is growing activity to look at science culture more deeply. A comparison of the Royal Society's publication on Research Networks (Royal Society, 2011) and the outputs of their Research Culture workshops and conference in 2018 (Royal Society, 2017, 2018) are notable in their shifting emphasis. The former being a report by learned fellows, the latter being a participatory document which engaged early career researchers and 'told the story' of research collaboration through scientist experiences.

While the Royal Society reports note immediate challenges to address a lack of diversity and poor conduct in academia, a particular focus in western research on a "…hypercompetitive research culture … with its focus on a very limited set of 'brick's' combined with the cult of the superstar scientist" has also been identified as a systemic issue (Royal Society, 2018, p.15). The institutional aspects, which have been considered to reinforce this culture, alongside the challenge of researchers examining their peers and practices, are considered in relation to approaching this research the following section.

3.2.3   Global University Rankings – the institutional view of bibliometrics

Around the time Albert and Barabási were identifying the phenomenon of scale-free networks in collaborative science, a team at Shanghai Jiao Tong University were drawing on bibliometrics to benchmark China's research capability (see Liu and Cheng, 2005). Rankings enthusiasts in the media world – notably the Times Higher Education group – saw an opportunity to extend their national rankings to one which went global. The resulting phenomenon of the Global University Rankings (GUR) initiatives, particularly in the response by the global Higher Education system and the subsequent impacts, is well documented (Safón, 2013; Marginson and van der Wende, 2007; Harvey, 2008).

Unlike earlier rankings which emphasised student satisfaction, such as Quacquarelli's QS ranking, the Shanghai Jiao Tong team incorporated bibliometrics and other research measures, including incumbent Nobel Prize winners, into their institutional ranking. This was seen to effectively amplify the relative 'value' of institutional measures based on research indicators. In this way bibliometrics data, compounded as 'value' through GURs, were strongly weighted for overall institutional 'performance.' As a result, a new race ensued amongst the 'Research Intensive Universities' (Marginson, 2009).

Although rankings of universities had been a long-term activity at a national level in the US and the UK, the arrival of GURs was seen to play into the "… idea of 'world-classness' in higher education is an emergent phenomenon" (Amsler and Bolsmann, 2012, p.284). GUR studies also suggest the 21st Century HEI population was now acting as a system which was highly responsive to externalities. In many cases the 'world-class' university was now able to leverage their research credentials to compete for the international student market (Marginson and van der Wende, 2007).

In Andrew Rossi's film the Ivory Tower (Rossi, 2014), Rossi charts the institutional 'arms race' in the US at a time university debt had outstripped mortgage debt. Rankings and marketing policies were seen by US academics as skewing institutional offerings in an effort to 'attract the next 16 – 17 year-olds.' Here the view was a compounding effect between rankings and competition that the "… the corporate model has actually bled into that world as well" (Brown, 2014).

I highlight the example of GURs to emphasise a case from which a CoE might 'observe' an aspect of the HEI through the lens of institutional logics (Thornton et al, 2012). In this case the 'logic' of university reputation has apparently been amplified by the GURs, which were largely fed by bibliometric outputs. This is not to say the response to GURs is

logical. Despite well understood limitations of bibliometrics (see Royal Society, 2011, p. 23), their association with rankings appears to have become highly interwoven into institutional legitimacy.

Legitimacy and reputation are seen as strong institutional logics. In their study of CoEs in

Norway and Sweden, Borlaug and Gulbrandsen (2018) identify 'excellence' and 'innovation' as logics linked to research which are taken as proxies for the 'dominant logic' of institutional reputation. It is no surprise then that both bibliometrics and institutional logics have been applied to evaluate the relative value of Research Centres from an institutional perspective.

Although I do not consider GURs in further detail, I use this amplified response to GURs as an example of 'institutional logics' which CoEs might be expected to 'experience' in their interactions with the HEI.

3.3 Researching researchers - Ethics and other anxieties

Before I step through the methodology in more detail, I also want to provide some background to my approach in a study which engages fellow researchers. Despite a renewed interest in exploring the internal workings of science, there is perhaps some caution in a sociological study of scientists. As Latour notes from his experience of the 'Science Wars': "…they might have concluded that the white purity of science should never be sullied by the dark and greasy fingers of mere sociologists" (Latour, 2005, p.100).

A similar study of scientists at WEHI in Melbourne in the 1980s by Charlesworth et al (1989) was also rebuked by biological scientists. Bringing Foucault into the laboratory was just one among a number of problems. Lewis Wolpert writes "…[Charlesworth et al] also do not understand the revolution molecular biology caused, and instead concentrate on the idea that molecular biology was a philosophical movement based on the conviction that all biology could be explained in terms of physics and chemistry" (Wolpert, 1989). However, as noted in the literature review, two prominent physicists turned sociologists, Harrison White and Duncan Watts, suggest the fields of sociology and network science offer prospects for more cordial engagement.

Firstly, I look at managing ethics in ways which align with similar small and specialised cohorts of individuals. Secondly, I outline ways that I managed a personal approach to being a researcher. I then consider how a qualitative approach can engage with those working (in predominantly) empirically framed fields of science.

3.3.1 Ethical considerations – don't quote me on that

Despite Latour's cautionary tale, he also notes the importance of identifying suitable candidates for sociological studies of science. He compares two observer, the first shadowing a head of a laboratory as they crisscross the globe, while another observes a researcher at their laboratory bench. At one point the observer of the global researcher notes in their log "…blank, too exhausted to follow" (Latour, 2001, p.154). Meanwhile the observer at the laboratory enjoys a very different view. Their more stationary scientist declares "…I am just doing science" (Latour, 2001, p.155).

Australia's CoE Programme is represented by a relatively small and readily recognisable group of research leaders. There is potential that many will be Latour's head of the laboratory, perhaps also distant from the direct 'science' of the CoE. Nevertheless,

they are more likely to be able to provide a view 'from' the CoE than the researcher embedded in the laboratory. Having taken the decision to engage senior leaders in the CoE in my research, this can create a challenge in assuring a level of anonymity for the contributors.

Wiles et al (2006) considered the ethical challenges in researchers researching their peers. In particular they note that confidentiality and anonymisation of science specialists is particularly difficult. For example, although they follow an ethics process which assured participants of the use of anonymised quotes, they "… were aware that this would not necessarily mean that study participants were actually anonymous to others in the research community who would be likely to read the study publications" (Wiles et al, 2006, p. 292). In their study, none of the researchers interviewed (n=17) agreed for their names to be included in the report and seven (7) did not consent for their data being archived in an institutional data repository.

Further there is a need to anonymise the respective organisations. This can be important to assure the research is not seen as an evaluation or 'report on' the CoE Programme – of which there are many. For the purposes of reporting findings, all references to institutions or CoEs are referred to as HEI1 or 'the CoE' etc. Reporting of some findings is limited as a result, but this does not affect the research analysis. However, as the ARC is central to the Programme as the major funding body, direct references to the ARC were retained.

The ethical approach was guided by ethics specifications of Monash and Warwick Universities. This was revised in stages and informed by the research outputs as each study progressed. For example, the informative study conducted at the International Network Organisation of Research Management (INORMS) Conference, described in more detail below, provided an opportunity to walk through and subsequently redesign aspects of the research approach for the CoE study.

3.3.2   Walking the walk – becoming a social scientist

A second challenge for understanding the roles, processes and systems of science directly, is taking an objective view while being embedded in the research environment. In my case, I also had to step outside my earlier professional view of the institution. This had naturally been shaped by pre-existing experiences and interactions with institutions and researchers.

In earlier work I adopted an interpretation of grounded theory (Lawrence and Tar, 2013) to walk through the literature related to the HEI response to the Global Sustainable Development Agenda (Power, 2018). I complemented this with Latour's Actor Network Theory (Latour, 2005) – which Latour also describes as a methodological approach – in this case by 'following the actor.' I found adopting these practices and approaches helped learn appropriate practices to 'relearn' a level of naïvety about the environment and allow me to reduce any overly subjective examination of the material.

In the case of the Informative study at INORMS I also designed a component to retain my personal distance from the interpretation of outputs. As noted earlier, by asking participants to re-sort the same interactions into any other groupings they saw – I adopted an approach of taking a step back from the research design.

In the subsequent CoE interviews I was then able to avoid suggesting any particular interactional sets to the participants. However, the semantic questions, piloted with the Informative study focus group, were redesigned and retained as pre-interview prompts for the CoE study. These were generally effective in prompting discussions around the HEI-CoE relationship and environment by purposefully proposing slightly dialectic positions for the participants to consider. This approach was also aimed to elicit a level of reflection and discussion.

In the case of a methodical analysis of the data provided by the empirical CoE study, consideration of emergent themes also acted as a step back from my initial attempt to apply an overly focussed theoretical lens. Writing by others, which reflected on personal processes in approaching qualitative research, such as Blair (2015), also provided a helpful guide.

3.3.3 Straying across the field: Can a qualitative study engage empirical scientists?

A third consideration in researching researchers is the slightly intimidating prospect of interviewing busy Leads of large and complex Research Centres. In particular, how does a sociological researcher, armed with a set of rather vague prompts, enter the world of a senior empirically driven scientist? Yang provides a perspective in approaching qualitative phenomenological research, which may go against the empirical scientist mindset. Noting Patton's definition that "… (Husserl's) phenomenology may be defined [in part] as the research paradigm that is a reaction against the positivist paradigm" (Yang, 2016, p.3).

This reaction against the positivists as holders of absolute truth could only end in schism (Brown, 2001). Brown charts the infamous case of Sokal's Hoax, where Sokal – a senior physicist - successfully published a 'nonsense article' in a journal (albeit not peer reviewed) of postmodern cultural studies. Mud-slinging toward Latour in particular, who had pointed out the potential for social constructivism in science, ensued. This hit a high point with Gary Kamiya's applause for Sokal in the "Transformative Hermeneutics of Total Bullshit" (from Brown, 2001, p.14). The furore dragged behind it the political transpositions of science from the political left to the right and so on which Brown also chronicles. As Latour notes "… during the somewhat silly episodes of the 'Science Wars', it was mainly in the name of the Left that the fight against science studies and especially ANT was waged (Latour, 2005, p.251),

Work by Charlesworth, Farrall, Stokes and Turnball (1989), which documented 'Life among the scientists' during the rapid rise of molecular biology at the Walter and Eliza Hall Institute in Melbourne, was met with criticism for taking Foucault's social constructivism into the lab (Wolpert, 1989). Fortunately, other studies (outlined in more detail below) have engaged researchers on their experiences in the institutional environment with less surprise. However, we see a recent tendency to see 'the Research Centre as a firm' and an approach to seeing the Research Centre in institutional terms, particularly in relation to its potential as a return to investment to the state, in order to seek less contentious findings. As noted in the literature review, Research Centres can also be simply treated as problematised, organisational environments or an extended 'view of the firm' (Etzkowitz, 2003).

Views of the outputs of science as a social construction via their societal interpretation have been considered by Bijker et al (2009). They note Sheila Jasanoff's work in ways science becomes 'known' as a part of 'civic epistemology.' They also propose a more recent shift which recognises 'co-production' in science which diffuses some of the (perhaps) artificial tensions between the sciences. In the case of empirical science and its application to policy development, they note that co-production allows for "...science to be understood as neither a simple reflection of nature nor a mere epiphenomenon of social interaction" (Bijker et al, 2009, p.43).

The quote below exemplifies the paradoxical challenge for CoEs working in an emerging field of science within the dominant political discourse:

' … But the truth is that if you look at cancer, people say you know 'blah blah blah's invented a cancer medicine' and to be honest you know 99% of people don't know

what the hell it's about, they just hear cancer, medicine, treatment and that's it. Whereas for us you know we're actually, quite frankly we're in a very exciting space .... but … it's a space that's … a double-edged sword. There's a lot of negative sort of commentary around [our science]' RL12.

This challenge in recognition is even charmingly described at the personal level:

'...But you know, I show what we're doing to my family, they say, yeah, that's kind of interesting' (laughs) … but maybe that's OK. You know if something great arises you know it will filter out' RL12.

Although outside of the scope of this research, it is important to recognise that the wider institutional environment may have a far greater impact in relation to how outputs of the CoEs are recognised and, perhaps, promulgated to form part of this 'civic epistemology' over any debate of what constitutes 'hard' science. Conversely, this research reveals the potential for new modes of storytelling in science which engage the public space.

3.3.4　　　Moving past the science vs science divide

Nowotny, Scott and Gibbons concluded at the end of the millennium that "society as a whole has been permeated by science" (Nowotny et al, 2001, p.3). However, we can reasonably ask how we went from that bright day to the current phenomenon of successful counter narratives of science in politics and the media. Why, despite an overabundance of data and scientific consensus on anthropogenic Climate Change, have some political classes successfully generated an alternative view and convinced many people in the process?

By combining a sociological approach which links to network science, I was also aiming to further understand the nature of science development in institutional environments – noting some of the inherent challenges in linking these paradigms. However, structural aspects of linking social and natural sciences, even at the global level have proved challenging. Mooney et al (2013) note the case in the 1980s of the International Social Science Council (ISSC) seeking to establish a global change programme independently of concurrent endeavours in the earth sciences.

At a community level Latour pre-empts the Coronavirus pandemic of 2020 as the intertwining of natural and social science challenges, "…Those quarantined because of the SARS virus painfully learned that they could no longer 'associate' with parents and partners in the same way because of the mutation of this little bug whose existence has been revealed by the vast institution of epidemiology and virology" (Latour, 2005, p.7). Nevertheless, how did wearing a face mask, which is shown to be a beneficial contribution to reducing the risk of transmission of Coronavirus, so readily become leveraged as a political choice? These glaring anomalies in the social world may be bewildering to empirical scientists, but perhaps not so surprising to those working in the social sciences.

The world of science as a site of sociological study can even feel foreign for researchers seeking to understand how 'other' scientists work. In research on the operationalisation of their own Research Centre, Boardman and Ponomariov note "… the interview was open ended and inductive, given how little we knew … about what center directors actually do" (Boardman and Ponomariov, 2012, p.80).

Yang's proposition of adopting a method based on "Husserl's radical scepticism" and the grounded theory method provides a useful start for a naïve approach. Yang recommends that "… qualitative researchers [can] be aware and become free from pre-supposed conceptions" (Yang, 2006, p.1). This approach is also noted to support a study

design where the "… researcher actively support[s] the participants' creation of meanings about their experienced phenomena" (Yang, 2006, p.7). Given the objective of the interview was to gain 'observations from' and 'about' the CoE, the interviews of the CoE Leads followed this intention and the prompts were intentionally left as open as possible.

3.4 Research studies

3.4.1   Integrative Literature Review – supporting the theoretical analysis

Through the literature review process, I explored to what extent institutional theory has been applied to studies of complex systems. A search through Web of Science for both 'institutional theory' and 'complex systems' in any field returned three (3) papers. A search for terms 'institutional theory' and 'network science' in any field returned no results. I reasoned that if evidence of a phenomenon in research collaboration was described via the 'new' field of network science in 2000, why wouldn't this be of some interest to institutional theorists?

This finding lead to a more systematic mapping of search terms to understand any integrated studies as well as any indications for an apparent gap. Initial explorations identified suitable search terms which were then applied to systematic literature searches conducted via Web of Science databases through their InCites search tool. Searches were made as topic searches on the primary term to gain an indication of the relative contribution to each field (i.e. to obtain a denominator). Searches were filtered to articles only. Intersecting literature sets were identified by paired term searches, i.e. institutional theory (A) AND search term (B) to identify the number and group of articles. This process was fully iterated for all terms three times to produce the output shown in Figure 3.1 below[12].

The output diagram (Figure 3.1) from the series of searches is based on a literature mapping approach. Here the topic searches and the figures in each 'bubble' are the total number of articles for each term with the number of intersecting studies with institutional theory also shown. The notations in Figure 3.1 indicate highly cited references for each grouping. The overlays are closely indicative of relationships across the literature but are not absolute. For example, six (6) articles which relate to Agency Theory also refer to Complex Systems. Authors with citations data within the bubbles of the diagram indicate highly cited articles which link to each theoretical field.

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[12] The diagram shown in Figure 3.1 was based on a similar design by Joanna Choukier, used with permission (personal communication 2018)

NETWORKS 1,236,916

NETWORK THEORY 6,519

Albert & Barabasi (1999) 17,261

Barabasi (2009) 833

151 Newman (2003) 9,169

LINK TO COMPLEX SYSTEMS* 26,869

AUTOPOIESIS^ (0 / 29)

EVOLUTIONARY THEORY (14)

Silvestre (2015) 105

SENSEMAKING (32)

COMPLEXITY THEORY (6)

COMPLEX SYSTEMS (3)

Weber & Glynn (2006) 200

Based on Web of Science Searches conducted July - November 2019
SEARCH by TOPIC
FILTER #ARTICLES
Sub Search All Fields For
Institutional_Theory + TOPIC (eg theory) (#Articles)
*based on a schema by Sayama (2015)
^ No cross reference to institutional theory

48

26

57

NETWORK SCIENCE 952

344

INSTITUTIONAL THEORY 3,727

GAME THEORY (6)

SOCIO-POLITICAL-ECONOMIC FIELDS

ECONOMIC THEORY (28)

Chatterji & Toffel (2010) 162

87

RATIONAL CHOICE THEORY (6)

POLITICAL THEORY (5)

DISCOURSE THEORY (4)

29

Watts & Strogatz (1998) 19,388

DiMaggio & Powell (1983) 13,766

105

Wright, Filarorchev et al (2005) 802

AGENCY THEORY 2,884

INNOVATION THEORY (11)

CONTROL THEORY (3)

STRUCTURATION (29)

35

COLLECTIVES 122,929

11

3

Barley & Tolbert (1997) 976

After filtering for articles in socio-economic and related fields, Elinor Ostrom is the most published in this field with 38 publications

Ostrom (2000) 1,200

108

ACTOR NETWORK THEORY 1,967

INSTITUTIONAL AND RELATED THEORIES - BIBLIOMETRIC MAP

MEGAN POWER | January 6, 2020

This mapping is included here as it establishes the basis for the methodological approach for the integrative literature review. As shown, the mapping indicates a potential gap in the literature which could be understood by exploring the two bodies of literature in an integrated approach.

The purpose of an integrative review is to "... create new understandings of a topic through one or more forms of synthesis" (after Torraco, 2005, p. 357). Thornton et al (2012) adopted a similar integrative analysis in narrow sense to consider the literature in neo-institutionalism in relation to that of institutional logics. Similar reviews to bridge organisational studies with network concepts have been undertaken by Stadler, Rajwani and Karaba (2014) to consider aspects of the exploration and exploitation dilemma. Here they look at network theory, drawing on Granovetter's concepts of ties and Burt's structural holes in relation to competition, without extending into the more recent work in network science.

Some interesting intersections between institutional theory and network science were revealed. For example, a search for the term 'collective', returned work by Watts and Strogatz (1998) on 'small world networks' and DiMaggio and Powell's (1983) seminal article

on neo-institutional theory as the two most highly cited articles. Within the field of knowledge on 'collectives', Elinor Ostrom's work has a strong overlap with institutional theory in relation to collective rationality (in common with DiMaggio and Powell) and in ways which also relates to more network-like organisational forms.

A wider search for "institutional theory" AND "networks" returned 344 articles. The articles identified represent a relatively recent endeavour. All papers were published post 1999 and all were considered for a more detailed review. From these, 79 articles were selected as 'the study set.' The criteria for selecting papers aimed to provide adequate examples of papers within the domain of Higher Education, but also to consider wider domains which might demonstrate novel approaches in their research approach. The criteria were:

● Breadth - ie articles which considered broad perspectives, eg were globally focussed and/or which specified institutional theory development were selected. (16 articles)

● Sector perspective - Higher Education and/or potential Research perspective articles were included to provide a specific sector view. (26 articles)

● Highly cited papers – papers with at least 3 citations or more were selected.

● Recent studies published in the previous two years

● A 'reading' of titles was also used to select articles which might adopt novel approaches to applications of institutional theory and/or network methods

In order to understand the context of theory in relation to these papers, the selected papers were reviewed alongside foundational and reflective papers in both institutional theory and network science. This gave three sets of papers to support the analysis as shown in Figure 3.2 below. This approach aimed to identify: 1) whether changing perspectives in relation to networks and institutional theory are evident in organisational and theoretical studies; 2) whether researchers drawing on institutional theory in more recent contexts were also engaging with new network perspectives and 3) whether a lack of engagement between institutional theory and network science is occurring and, if so, why.

The institutional theory grouping was developed by revisiting the seminal literature in institutional theory and was then expanded to capture related subsets which included

reflections of primary authors and reviews (or critiques) by others in relation to earlier writings. The selection of seminal texts followed an approach relevant to developing an integrative review outlined by Torraco (2005). This aims to incorporate both "… recently published literature and older literature" as part of the systematic search in both fields (Torraco, 2005, p.360).

By identifying later works as well as proponents, a subset of reviews and critiques was also established. A similar approach was applied to the network science literature. Given the relatively recent emergence of network science, originating authors can be traced to a more distinct period when the term 'network science' was coined by Barabási (2002). This relatively recent field is nevertheless growing rapidly given its application to network modelling across domains of relevance to both social and natural sciences.

In looking at later works and reflections by foundational authors here, a reading of 'social science' considerations was applied – once again to look at convergence of interests which may be of relevance to further applications of institutional theory in later works and reflections by foundational authors. Here, a reading of 'social science' considerations was applied – once again to look at convergence of interests which may be of relevance to further applications of institutional theory.

Figure 3.2 Literature sets for integrative review and analysis

I INSTITUTIONAL THEORY FOCUS	II NETWORK SCIENCE FOCUS	III POST 2000 STUDY SET
IT1 Foundational Papers in Institutional Theory (20 papers) 1971 - 1998	NS1 Foundational Papers in Network Science (9 Papers) 1999 – 2002	SS1 Institutional _Theory AND Networks (Web of Science search 1990 – 2019) (344 papers)
IT2 Reflections and Critiques by key authors (12 papers) 1983 - 2005	NS2 Reflections by key authors (3 papers) 2004 and 2009	SS2 Subset for analysis (2000 – November 2019) 82 papers, of which 3 papers published pre-2000 were added to IT3)
IT3 Reviews of key author/s by others (18 + 3 papers identified from WoS) 1994 – 2016	NS3 Further studies by key authors & reviews by others (9 papers) 2005 – 2019	

3.4.2 Informative Study: The research professionals' focus group

3.4.2.1 Tapping new perspectives: Considering interactions.

Based on the literature review, the focus group study aimed to 'tap the perspectives of the research profession' in order to explore the apparent duality of a Research Centre's function as both an institutional entity of the Higher Education Institution (HEI), and as a node for research connections within a rapidly changing networked environment. In particular, the relatively recent establishment of the research management profession signified potential value to seek their input to better understand the interactions between the institution and the network.

While numerous researchers have considered Research Centres and their relative impact, particularly in comparison to the traditional delivery of research by university departments and industry engagement, these have often relied on output measures of research using bibliometric analysis and / or drawn on the input and views of Research Centre directors.

By applying a sociometric approach based on Crane (1969), who accounted for research outputs in relation to social interactions, the focus group was designed to gain a broader view of the research system by including the research profession. Secondly, the focus group study aimed to see whether research professionals could contribute richer information to address Barabási's call to better understand 'interactions along the network' (Barabási, 2009).

A Weberian view proposes the professions are a bureaucratic form which works directly to structure institutions. More recently the professions have been described as a type of "...exclusionary social closure underwritten by the state" (Saks and Adams, 2019, p.2). The neo-institutional view proposed by DiMaggio and Powell (1983) also considers how professions establish networks and, in the case of informal organisations, act to form specific roles to engage with like professionals in formal institutions.

However, in the case of professions aligned to science, there are few studies available about the work of the research professional in Research Centres. A study on the role of postgraduate trained research managers in Australia by Berman and Pitman (2010), usefully considers this group as occupying a 'third space' in the institution. More recent studies have also highlighted the global growth and demographic of the research profession and emphasise their increasing contribution to global research development (Kerridge and Scott, 2018).

The design for the focus group was based on the principle that research managers, particularly those attending an international conference in their field, would be cognisant of both the 'invisible college' within research institutions (Kuhn, 1970; Crane, 1977) and would have an appreciation for global research networks.

The opportunity to conduct a focus group activity at the INORMS Congress in Edinburgh in June 2018, represented unique access to a group of international research professionals.

Participants who participated in the forum group were self-selecting. That is, they had selected to attend the workshop event at INORMS through the usual delegate registration process. Information about the focus group and data capture component of the workshop was forwarded via the INORMS conference team to registered delegates, as were additional documents including copies of the ethics requirements and consent forms. The focus group was run by myself as the researcher with a Chair supporting the session from the INORMs conference team. Eighteen (18) participants from six (6) countries contributed to the interactive session.

While looking at general interactions, the methodology also considered symbolic interactionism (after van den Hoonnaard, 2013) as a theoretical perspective to approach studies of institutional complexity. In this way the first activity of the focus group was to see to what extent research professionals actively interacted or identified their roles with formal structures of the institution. The second stage of the focus group, which allowed participants to rearrange their interactions, followed an approach which is described at an organisational level by Hallett et al (2018). They note that symbolic interactionism also allows people to analyse *how they work* which also considers that institutions and interactions are not oppositional but rather that together they can provide a view of an "inhabited institutionalism" (Hallett et al, 2009, p.4).

The Expert Focus Group objectives were to:

- capture the perspectives of an expert group on the role of Research Centres in the HEI.

- generate data based on expert perspectives on Research Centre interactions which can inform the next stage of the research.

- engage an expert group in participation in the next stage of the research.

The focus group session began with an introductory presentation of findings from the literature review to date. The presentation aimed to 'prime' and orient the audience by giving some background to the research project which included a summary of the Research Centre studies which had informed the research to this point. At the conclusion of the presentation attendees had the option to leave if they chose not to participate in the focus group component. In all 18 participants remained and 17 contributed actively to the session.

Full details of the INORMS Focus Group study, including data of the participant cohort is available in Appendix II.

3.4.2.2 Mapping interactions

Interactions were volunteered by each participant via 5 post-it notes. Participants were asked to highlight any 5 interactions over a three-month period of relevance to them. To support engagement in the discussions on interactions, participants had an opportunity to discuss their notes with others. They were then asked to assign their interactions to the set of institutional structures that I had defined. The structures were: 'The Core HEI, 'The HEI Faculty/ Department', 'The Research Centre, 'Research Centre Partner, 'Research Centre Sponsor', Government, Other.

Participants were invited to look at the interactions noted under each grouping and discuss any of interest. These groupings of notes were then photographed. I then removed post-its and gave a bundle of each to small discussion groups of 2-5 people. I asked each discussion group to look at the interactions and see whether they could arrange them in a different way – that is – were there any other groupings evident to them?

This proved beneficial. For example, one group noted the group size and suggested regrouping based on whether the interactions were: *1:1*, *1:group* or *general transmit interactions*. Another group suggested regrouping based on the type of activity – eg such as whether the interaction related to type of engagement, eg *communicating* with stakeholders or *reporting* to funders. The third group did not suggest any alternative grouping for the interactions they reviewed. These new groupings were then posted up and photographed.

The post-it notes were all prepared for analysis by first transcribing into an Excel spreadsheet with each interaction forming a record. All notes were transcribed as written. In total 80 interactions were captured and recorded. The interactions were matched to both the researcher proposed grouping or the participant proposed grouping. Based on photographs the 'sets' were noted in the same spreadsheet.

3.4.2.3 Focus Group survey

Participants were also asked to complete a pilot survey. The purpose of this pilot was to identify the potential suitability of two question types for the CoE Study. Twelve participants completed the pilot survey.

The survey consisted of a short set of profile questions in relation to level of experience and current role as potential variables. The survey was made available both on paper and electronically. The first main question type was a set of 5 semantic questions which was ranged on a continuum scale. This asked participants to respond in relation to their perception of the Research Centre position from a Janus view in relation to its environment. For example: Would you say the institution is more a 'home' for the Research Centre or more of a 'host'? The purpose was to see whether participants were readily able to respond to potential dualities. The five questions covered institutional and network-like characteristics of views of legitimacy, embeddedness, autonomy, adaptability and global orientation.

The pilot survey also asked contributors to provide information about interactive frequencies. These were multiple response questions. The interactive groupings were based on a level of personal experience working within a research manager role, but were also informed by the focus of studies on Research Centres outlined in the literature review.

3.4.2.4 Learnings

Parker and Tritter (2007) note limitations with focus groups both in terms of recruitment of suitable participants and as sources of quality data. However, they also note focus groups offer an opportunity to capture relatively "… large amounts of qualitative data in exchange for relatively little face-to-face researcher contact" (Parker and Tritter, 2006, p.23).

As indicated in Figure 3.3 below the outputs of the focus group proved valuable in directly informing the approach to the CoE Study. Firstly, the research professionals demonstrated a highly consistent level of knowledge. This indicated that the profession is highly globalised, suggesting that findings with an Australian cohort could have relevance for research professionals in other countries.

The outputs also illustrated complementary as well as some potential contradictions between the interactions noted by the participants as well as the responses to the semantic and survey questions. For example, although all participants were likely to see the Research Centre as being high - highly global, their frequency of interactions with international partners was recorded as relatively low.

The Focus Group study achieved a positive outcome in informing ways to approach the subsequent CoE study. Firstly, the outputs and discussions refocussed attention on an opportunity to tap into deeper narratives through the interview phase by *not* prescribing pre-determined types of interactions. Secondly the Focus Group demonstrated a value in retaining the use of the semantic question set, but with modifications for terminology. Thirdly, the opportunity to retain the contribution from professional research managers by interviewing co-leads of research centres – that is both the research and the professional leads - was seen to offer potential for a greater range of perspectives in relation to experiences of the institutional environment.

Figure 3.3   Research design, recruitment and data gathering for the Focus Group and CoE Programme Studies
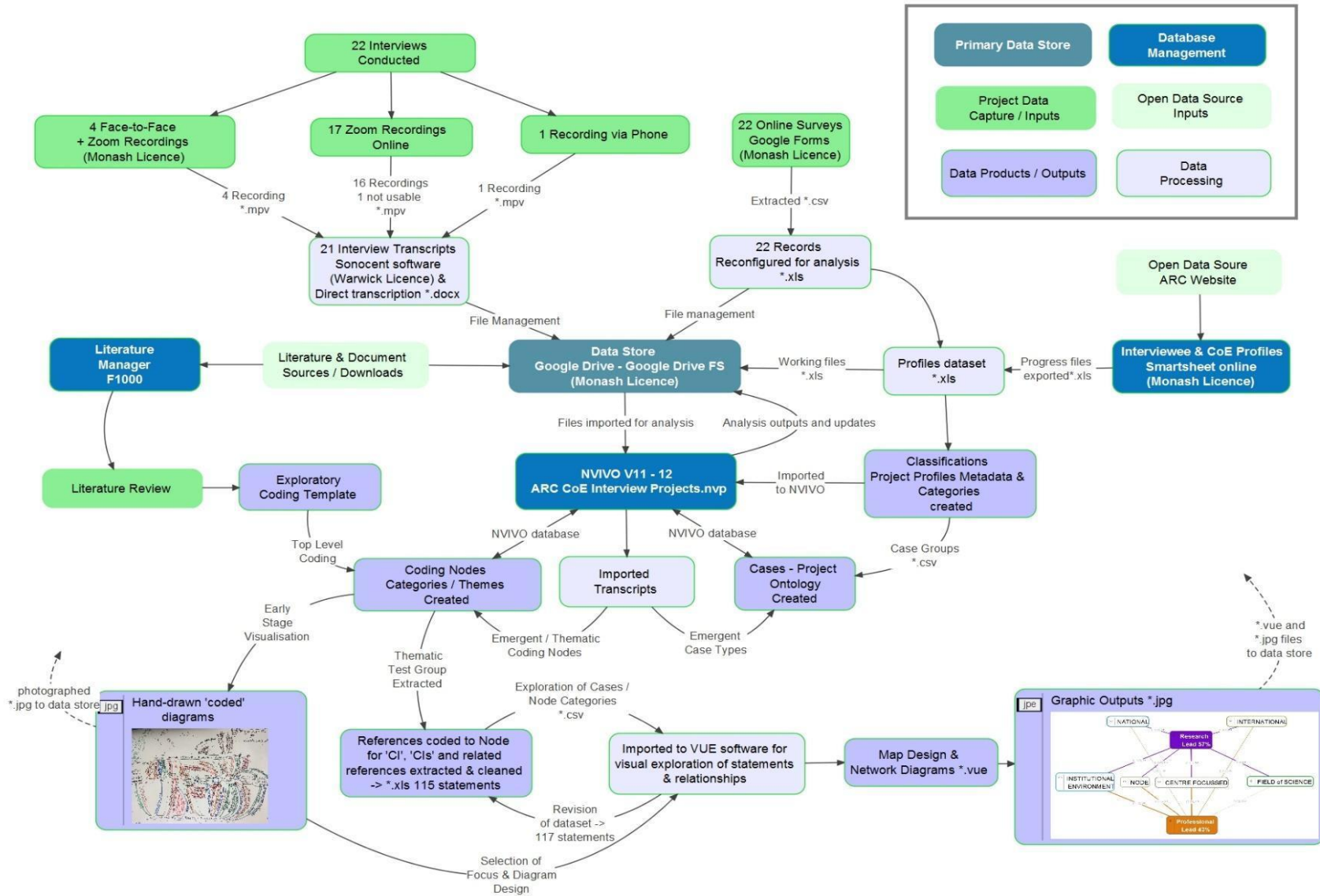
3.4.3   Empirical Study: The Australian Centres of Excellence study.

3.4.3.1   Selecting the case

Based on the literature review, the Australian CoE Programme was considered to offer value as the empirical study from which to view both the institution and the network. Since its inception in 2001, the CoE programme aims to produce research excellence in fields demanding high levels of interdisciplinarity by engaging "researchers of diverse disciplinary backgrounds and skills to work together to build networks" (ARC Annual Report, 2001, p.15).

In particular, the CoE Programme has a funding cycle which establishes 'new' CoEs as cohorts every three years with a similar baseline funding. This offers an opportunity to follow dynamics of each cohort from a similar starting point. Secondly, each CoE under the scheme is funded for a designated seven (7) year period, allowing an opportunity to note any distinct temporal observations. This comparable starting point and adequate timespan, also potentially allow time for participants to also describe the self-organisation of the CoE.

The ARC Centres of Excellence Program was described by one participant as the 'jewel in the crown' of Australia's National Competitive Grants Program (NCGP) which provides support for a broad range of research and research training. This fits within a wider context of Australian national research funding which is complemented by the National Health and Medical Research Council (NHMRC) and the Australian Antarctic Program as well as national research agencies, in particular the Commonwealth Science and Industry Research Organisation (CSIRO). As shown in Figure 3.4 below, the CoE Program represents the most substantive and long-term investment in Australian programmatic research objectives and complements the Discovery programme which supports individual and team research.

Australian Research Council (ARC) National Competitive Grants Program

- **DISCOVERY SCHEME (Individuals and Teams)**
  - Future Fellowships $160-228k up to 4 years
  - **Discovery Projects**
    - Indigenous Researchers $160-228k up to 5 years
    - Early Career Researchers DECRA $AU106k
    - Discovery Projects $AU30-500,000 for up to 5 years
  - Australian Laureate Fellowships Professorial Level E

- **LINKAGE SCHEME (Programmatic and partnerships)**
  - ARC Centres of Excellence $AU1-5mill/year 7 years
  - **Industrial Transformation Program**
    - Industrial Transformation Research Hubs $AU0.5-1mill 3-5 years
    - Industrial Transformation Training Centres Scaled up to $1mill 4-5 years
  - Linkage Projects $AU50-300k 2-5 years
    - Linkage Infrastructure, Equipment and Facilities (LEIF) $AU150k
  - Special Research Initiatives Varies

The empirical study for my research focuses on three (3) cohorts of CoEs funded in 2011, 2014 and 2017. At the commencement of the study in 2018 there were thirty-four (34) Centres operating, although some 2011 Centres (CoE11) were winding down or had closed around this time. However, this group represented a valuable overview across the CoE 'lifespan'. The study was also fortunate to be able to gather contributions from those with experience of CoEs across this period. This included those who had participated in a CoE from the inauguration of the ARC Programme in 2001. Individual experiences ranged from inception to mid-funding and coming to the end of their funding period, or having closed a CoE.

While all of the ARC Programs aim to engage Australian HEIs, the Linkage and Industrial Transformation Programs specifically seek to support collaboration with industry sectors. In contrast the ARC Centres of Excellence Program is more focussed on inter-institutional engagement with potential links to business. Figure 3.5 below provides a profile of the 141 instances of Australian HEI participation in the CoE Programme for the 3 cohorts considered in this study - for 2011, 2014 and 2017. As indicated, the larger research focussed universities in each state tend to act as administering 'hosts' for CoEs. The

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[13] Data sourced from Australian Research Centre (2020) An Overview of ARC Grant Opportunities
https://www.arc.gov.au/overview-arc-grant-opportunities

Australian National University has the most substantive participation rate while the University of New South Wales UNSW) actively hosts the most Centres. The most familial universities are the University of Melbourne and UNSW with partnerships in 6 CoEs and the average number of 'node' universities in a CoE is 5.2 (Range 3 - 7). Of this group CSIRO is also a partner in 13 of the 34 CoEs reviewed.

Figure 3.5 Australian Higher Education Institution participation in the CoE Programme for all CoEs funded in 2011, 2014 and 2017 by state, rate and type of participation[14] N=141
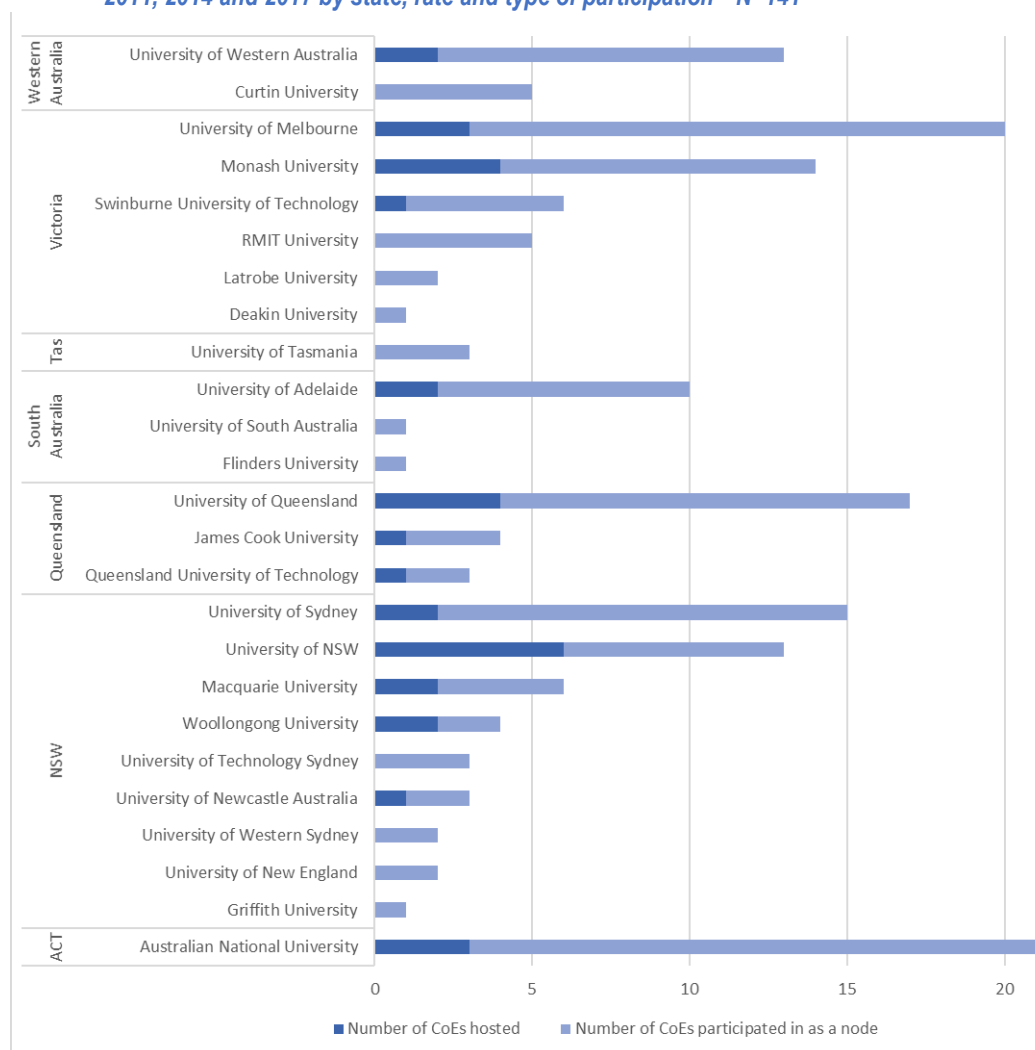
However, it is important to note that a feature of the 2017 funded cohort was that five (5) of the nine (9) CoEs funded were further iterations of those funded in 2011. In 4 cases, the CoE Leads: the Centre Director and the Chief Operating Officer, also continued in equivalent roles in the 'new' CoEs. While these iterations are 'new CoEs', in some cases with new partnerships, there is a level of continuity in some aspects of the CoE Programme for the period being reviewed.

Similarly, two of the CoEs funded in 2014 had 'previous' lives as 2005 CoEs and one CoE had received funding throughout the running of the Programme. This meant that a number of study participants were able to describe their current experience in relation to earlier periods in the CoE Programme. These longer lived or next-iteration Centres were also considered to offer an opportunity to look for particular institutional effects – such as institutionalisation – which might be expected to become apparent in any organisational form over a longer timeframe.

Although the Australian CoE Programme has not had any similar external qualitative study applied to date, equivalent studies in other national science systems provided a valuable cross reference for this research (notably Bell, 1996; Bourlag and Gulbrandsen, 2018; Wagner and Leydesdorff, 2005 and Boardman and Bozeman, 2007). Collectively these build a view of such national systems which serve for future reference. The context of research development in Australia was another important element in designing the research. The multi-partner nature of the CoEs also provides a national view of science development. Similarly, by adopting the CoE as a Janus, the study does not focus on any particular HEI, but has potential to look at both institutional and systems effects.

3.4.1.2 The Participants

The Australian Research Council (ARC) supported access to a list of Centre Executives of the 34 Centres of Excellence funded in Australia since 2011. Although openly available online, a formal list was kindly provided by the ARC Program Partnerships and the Director, ARC Strategy and Governance Section with an indication of support for engaging this group in the research. Given the prominence of the ARC I made the approach to ensure a similar project of this type had not already been undertaken and/or was not being planned. Also, I felt it appropriate to advise the ARC that I would be contacting participants in the Programme so that the distinction could be made by the ARC that this research was clearly independent of their Programme. Although the ARC was made aware of my project, no member of the ARC was involved in any aspect of the conduct, analysis or initial reporting of the research to the participants.

All CoE Leads from the 2011, 2014 and 2017 cohorts, that is the Research Director and the Centre Operations Officer (or their equivalent), were contacted individually by email and invited to participate. The final list was expanded from 64 to 68 possible contributors. The study sequence included a pre-interview survey followed by a semi-structured interview. Those who responded positively to the email were forwarded further information, including consent and ethics details and a link to the pre-interview survey. The CoE survey

and interview questions are given in Appendix III. Two additional Chief Investigators, who were not on the original list represented CoEs, also participated. One had a role as an 'institutional node leader' and had been engaged in the CoE Programme for over 15 years. The other contributor held a 'portfolio leader' role and had just joined the CoE Programme.

Participants were asked to complete a short survey online via a Google form ahead of interview. This survey included a revised set of five semantic questions tested with the Focus Group. Some terms were changed for the CoE study. For example, the term 'creative' was changed to 'flexible' as a more neutral option. These questions aimed to serve as prompts to engage discussion on tensions and perspectives, rather than provide formal quantitative data for analysis.

Two contributors responded to the survey only. One person declined continuing to the interview phase and the second person was unable to contribute further. Only one person replied to discuss why they were not interested in contributing to the study. Two positive respondents were unable to contribute to the study despite an interest in doing so because of unforeseen circumstances. In total 22 people were interviewed. The interview period was extended due to availability of some respondents. Importantly the extension allowed the participation of women Research Leads. This was considered of particular value to consider a wide range of perspectives and also ensured gender participation overall was at parity.

Figure 3.4 below provides a more detailed overview of how data captured from the pre-interview survey and the interviews were managed and processed. The pre-interview survey data is only lightly analysed from a quantitative view and this is briefly discussed in the findings.

On completion of the first analysis of the interview material a detailed report was shared with the participants. Participants were asked to comment on the report and to advise on any potential errors or misrepresentations. This was done ahead of a presentation of the study at the Australian Research Managers (ARMS) Conference in Adelaide in 2018.

Follow up discussions were held with six of the original interviewees with four further interviews conducted with participants face to face. These interviews provided clarifications and further suggestions but also validated aspects of the study in terms of areas of commonality recognised across multiple CoEs.

3.4.1.3 Processing the data – rich material and emergent themes

Most interviews were conducted for an hour and this was adequate to gain a rich and varied contribution from each participant. Most interview data was either saved directly via Zoom voice recordings as *.mp4 files or, in one case, was downloaded from a phone recording, also as an *.mp4 file. The data was imported into Google Drive initially for transcription. The various processes are explored in two stages and an overview of data processing is given in Figure 3.3.

Interview transcripts were made by me and transferred into NVivo for further exploration. I initially made a close reading and encoding of eight (8) interviews from end-to-end closely based on the institutional theory framework considered in the literature in relation to the HEI and the Research Centre. The aim here was to note places where interviewees were mainly 'looking to the institution', and then conversely to note where they were interacting or describing other areas of focus. Although I used NVivo software to support this process, my main aim was to use the software as an organising device, rather than as an analytical tool at this stage.

After the first eight (8) transcripts were mapped, I then adopted an approach to consider emerging themes in the narratives. Rather than imposing a predetermined framework or institutional lens on the data, I simply asked '… '… *What do people working within CoEs say about their experiences in the institutional environment*?' Given the rich material provided by the participants the emergent themes as proposed by Blair (2015). This suggested validity for further analysis after Creswell and Miller (2000). They propose that the "…researcher determines how long to remain in the field, whether the data are saturated to establish good themes or categories, and how the analysis of the data evolves into a persuasive narrative" (Creswell and Miller, 2000, p.125).

Boyatzis describes this type of thematic analysis as a "way of seeing" patterns in the research material and then encoding in such a way as to find emerging themes. He also notes that thematic analysis provides a tool for researchers and a translating device for "… those speaking the languages of qualitative and quantitative analysis" Boyatzis (1998, pp.4-5). Boyatzis notes that by adopting a clear thematic analysis, contributors in more empirical fields might be able to orient or identify with the findings as being rigorously reviewed. This was important in this case in reporting the findings back to the research community.

At the outset of the study I was interested in finding ways to better visualise the descriptions of 'interactions along the network'. As shown in the bottom half of Figure 3.4, I

used a combination of hand-drawn diagrams followed by manipulation in VUE[15] mapping software of extracts of coded statements to represent themes and these examples are shown and discussed in more detail. A summary table of the template codes and the thematic codes used in this report is shown in Appendix IV. (Please note some of the sub-codes have been removed from the table for clarity.)

Boyatzis (1998) did not consider thematic analysis as a 'method' in its own right, but rather an inductive tool for researchers to draw on. However, I have followed a similar approach as outlined by Nowell and others, who note thematic analysis as an "…iterative and reflective process that develops over time" (Nowell et al, 2017, p.4). The exception in my case was the use of a combination of NVivo as an exploratory tool, Excel as the organising tool to order statements and VUE software as a virtual surface to explore statements. Statements were imported as a *.dbf file into VUE and can then individually moved and linked to determine emerging themes, similar to traditional thematic analysis on a physical surface. This process allowed potential to make sense of any prospective themes.

The use of VUE also allows the statements to be viewed as tag clouds which are described by Viégas & Wattenberg (2008). The first wordcloud approach also traces to Milgram, who asked people to create a 'mental map' of Paris and then used font size to create a frequency of word use map (Viegas and Wattenberg, 2008, p.49). The further development of text mapping in a three-dimensional sense has been used in linguistics studies (Donohue, Musgrave, Whiting, & Wichmann, 2011) and word tags have also been used to examine interactions in learning communities (Conole, Galley, & Culver, 2011). These tools provide other means of sensemaking in viewing the transcript material.

In visualising, reaggregating and interacting with the statements via VUE - six main themes were established for the analysis of the material gathered through the interview process which are described in the next Chapter. In addition to the emergent themes, word frequency and observations reveals a (perhaps not surprising) high number of references to 'Chief Investigators (CIs)'. References to interactions with CIs were examined across all the transcripts in NVivo and returned 135 potential statements for further analysis.

Figure 3.5 below shows an example of handling the statements in relation to reference to the Chief Investigators.

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[15] Visual Understanding Environment Tufts University

From this initial mapping in VUE, qualifying tags are also captured from the underlying data to the statements to indicate variable weightings. For example, were a set of similar statements more likely to come from Research Leads? This allowed for further questions to be explored in the emergent theme. For example, did the description suggest 'how the CI group was interacting with the CoE or outside the CoE' or was the description more about 'how the interviewee interacted with the CI group'? This initial view of the data clarified the value in focussing initially on statements relating to the CI group to 'see where this took the analysis.'

3.1.4.4   Exploring the narratives

The interview data provided adequate deep material to support a narrative analysis across the transcripts. Options for exploring the narratives from both an institutional theory and a network perspective were explored. For example, 'origin stories' could be readily captured. The literature provides narrative examples, such as Barbara Czarniawska's 'LSE case' which aligns with the CoE origin stories which can come together with other statements to form 'a story of the CoE' (Czarniawska, 2009). From an organisational population point of view, narratives in common were also particularly powerful as 'emergent' forms. In noting the ongoing value of narrative approaches Mohr and White state; "…we know a great deal about how social networks are organised … [but] we know quite a bit less about how [their] stories are structured and how those structures matter" (Mohr and White, 2008, p.509).

In similar work to this study, Corsaro, Ramos, Henneberg, & Naudé (2011) and Ramos & Ford (2011) aim to capture actors' perceptions in organisational networks. The framework by Ramos and Ford captures levels of interactions to "…characterize an actor view with regard to his/her perception on who the 'focal' actor or groups of actors in the network is/are; On Themselves, On the Company, On the Surroundings" (Ramos & Ford, 2011, p. 453). These are similar to Mohr and White's proposed nested dualities of institutions; Self (Mind-Body), Group (Story-Network) and Field (Rhetoric-Social Organisation) (Mohr and White, 2008).

These levels were similarly applied in seeking narratives from the CoE participants who were asked to consider layers or personalised views from; within their role in the Centre, then to look at the Centre as a whole and then from the 'windows of the Centre' to consider the HEI and finally to take a birds-eye view and look back at the CoE in relation to the wider Research System and consider the CoE itself as a more global actor.

Extensions of the work on network pictures by Ramos and Ford, similarly apply three levels for consideration; ACTOR: as individual, DYADIC: as relationships between connected organisations and NETWORK as a description for the wider surroundings (Abrahamsen, 2016) and as 'networks in action' (Abrahamsen, Henneberg, & Naudé, 2012). Although the studies of Abrahamsen and others are based on considerations of more one-to-one (dyadic) inter-organisational links, their philosophical basis for understanding inter-organisational links is based on social constructivism (Berger & Luckmann, 1966), Gidden's structuration (Giddens, 1984) and draws on Weick's concept of sensemaking in organisations (Weick, 1995) and Latour's Actor Network Theory (Latour, 2005). These align closely to the institutional perspectives developed in this study.

The following chapter focuses on the narratives from the CoE. In particular these narratives are viewed through the lens of institutional theory. Firstly to understand the roles and activities of the institutional leads and then to consider their experience of the institutional environment in more detail. As discussed in the analysis, this research explored an opportunity to develop 'network narratives' by drawing on the multilayered networks set out by Watts (2004). As discussed in more detail in Chapter 5, the narratives also offered insight into both structural and functional aspects of potential formations of CoEs.

Chapter 4   An institutional life – observations and experiences

4.1   Introduction to the findings

I present the findings from the three studies in sequence, starting with the integrative literature review. The finding of each study aims to provide a view as a Janus – by first considering the institution and then the network aspects of the findings. As noted in Chapter 2, the 'network' bubbles through the work of institutional theory. In her case considering the London School of Politics and Economics, Barbara Czarniawska's title of "Pyramids or Anthills?", attests to an interest in exploring concepts of both the institution and the network - firstly, to understand the role of the actor-network evident in the formation of the LSE and then to recognise the emergence of a new institutional form (Czarniawska, 2009).

Like Czarniawska's case, the integrative review process was part analysis and part actor network, in following precedents and relationships across the literature. The findings cover an analysis of 79 historic or applied organisational studies published since 2000, which consider both institutional theory and networks. In giving these papers context, I relate the findings to four other subsets of literature. Two (2) subsets are a selection of foundational papers in either institutional theory or network science. The other two (2) sets are reflections by the same authors or reviews by others of their contribution in each field. As noted in Chapter 2, where I consider the work of DiMaggio and Powell (1983) and Watts (2004) in some detail, both the foundational papers and later reflective writings reveal a close sociological connection between the two fields of institutional theory and network science.

Torraco (2005) notes that most integrative reviews address either mature topics or new and emerging topics. However, the field of network science is still very young (Watts, 2004), while institutional theory is more mature (Scott, 2008, 2014). Nevertheless, the influence of key papers in their field have achieved an equivalent standing in their respective research communities.

Other indicators of possible intersection, such as 'collective rationality' in DiMaggio and Powell (1983) and 'collective dynamics' in Watts and Strogatz (1998), hint at potential to relate both conceptual developments to complex systems studies. Despite this apparent potential, the finding in the preliminary literature searches in Web of Science, as shown in Figure 3.1, demonstrates a current lack of intersection with institutional theory and network science.

The integrative review demonstrates a reconciliation between institutional theory and network science through sociological origins. Although there are challenges in the jump between sociological and natural sciences, the overlay of theory remains an important intersection of exploration. DiMaggio and Powell's conceptual exploration of 'the field' is just

one example (Martin, 2003), which aligns with interests in network science to understand the overall 'topology of the network' (Barabási, 2009).

The output from the integrative review is an open architecture framework which is outlined in Chapter 6. This extends Scott's three pillars framework for institutional theory (Scott, 1987; 2008) by connecting network science back to related connections in social theory. The circular design of the framework brings the fields of literature together and allows network science to be located within Scott's long engagement with "… the theoretical ripples" of institutional theory (Scott, 2014, p.136).

The second study, the Focus Group conducted at the INORMS Conference in Edinburgh in 2018 acted as an informant for the empirical study of the Australian CoE Programme. I provide the key findings here with a focus on those findings that particularly informed the approach to the CoE study. There were also 'moments' from the interactions in the Focus Group itself which helped shape my thinking about the approach to the CoE study. For example, the rearrangement of interactions data by the participants revealed the high one-to-one interactions between research professionals and researchers. This close synergy oriented the CoE study toward engaging the Co-Leads from the CoEs. The example also provided a case for a closer exploration of 'network-making' as a distinct interaction of the research profession.

Given the relative ease with which this session was conducted with international participants, the decision to focus on a single national research system was seen to be of equivalent value for wider cases. Rather than developing a more complex international comparative study, a more focussed study on the ARC's national research program was seen to offer an opportunity to be 'closer to' understanding the layers of local (perhaps institutional), national and global interests which may lead to network formation. This decision was fortunately borne out by a CoE participant who had recently returned from a conference in the US. They commented that '… all the problems are the same, it doesn't matter where you go.'

The findings from the CoE study form the main body of data captured for the research. As shown in Figure 3.2 most contributors to the study participated in both a short pre-interview survey and an interview. This provided interview transcripts from 22 contributors, representing 40% of the potential CoE leadership group at the time, and covering 17 (50%) of the possible CoEs across all three cohorts studied – from 2011, 2014 to 2017. Interviews were conducted between November 2018 and July 2019. The interview period was extended to allow an equitable representation of women as well as to balance the proportion of research and professional contributors to the study. The majority of interviews (17/22) were conducted and recorded directly via Zoom online.

The study achieved a balanced contribution from the CoEs represented. The ratio of Professional Leads to Research Leads was 1:1 and a gender ratio of 1:1 was also achieved. Of the 24 total participants, two (2) contributed to the pre-interview survey only and 22 participated as an interviewee. The level of experience was also broad. Eight (8) participants had held a leadership role in at least one earlier CoE cohort, while 13 participants had experience of one CoE to date.

The findings from the CoE study therefore represent a balanced contribution across the ARC Programme. However, there was a relatively higher representation from CoEs engaged in the physical sciences. Unfortunately, climate extremities during the period of the study meant some prospective participants from CoEs with a focus on biological sciences, were unable to contribute. As the purpose of the research was to gain an overview of the 'institutional life' of the CoEs in relation to the institutional environment, it is hoped the findings will also have resonance for those CoEs not directly represented in the study.

As noted in Chapter 3, the approach to the analysis of the CoE study data was through emergent themes and the findings are presented with this focus. The CoE study also aimed to consider the CoE as a Janus object. While the findings present the themes through a more institutional lens, the analysis in Chapter 5 explores the findings in greater detail through a network perspective. In establishing a synthesis of findings, the empirical studies are drawn together through the sources and findings explored in more detail in the integrative review.

I provide the key findings from each study below. Findings for the integrative review and the Focus Group study are summarised to allow focus on the more substantive findings from the empirical case of the CoE Study.

4.2 Finding divergence and convergence in the literature

The integrative literature review included a subset of 79 studies published from 2000-2019, which include both institutional theory and networks in any field in their article. A first level analysis was based on the study set's frequency of terms. This is based on word count analysis conducted in NVIVO. (A summary of this output is shown in see Appendix V). Papers are noted in relation to key theorists linked to institutional theory and extends to those perspectives in network science.

Across the subset, 'innovation' was the most prevalent term with 63% (50) papers recording 3 or more occurrences, giving an indication of the main focus of interest through the period. Prominent terms which relate to institutional theory, such as 'legitimacy' was found over

600 times in over 53% (42) of papers and 'norms' similarly at 56% (43) papers. 'Cognition' OR 'cognitive', which occurs in Scott's revised institutional theory framework (Scott, 2008), and is an element of Weick's work on sensemaking, was noted in 31% (25) papers. These papers also link to work by Weick on sensemaking, as well as reviews by Knight and North (1997) on the role of cognition on concepts of political economy.

Despite prominent use of network-like terms across the papers, such as 'complexity' in 50% of papers, 'complex systems' (4), 'nodes' (13) and 'clusters' (23), only one paper referenced Watts and Strogatz and no papers referenced the work of Albert-Barabási. In some cases, network terms tended to be used quite generically. As an example, Franssen and Kuipers (2013) make numerous references to networks and clusters, but use these terms in a more descriptive sense.

Here 'clusters' refer to publishing houses with common links and networks refer to actor networks, eg "Dutch editors use their networks of agents, friends and scouts to deal with the problem of abundance …", describing these as a gatekeeper network in the publication process (Franssen and Kuipers, 2013, p.58).

4.2.1   Institutional perspectives in the integrative review

The word frequency analysis performed in NVIVO found DiMaggio and Powell's 'isomorphism', remains a predominant consideration in postmillennial studies. Close to 50%

(39) of the 79 studies reviewed made substantive[16] reference to DiMaggio and Powell (1983) and, within these, 'isomorphism' was referred to across the articles 204 times.

When analysing theoretical uptake by authors across the study set it is clear that there is relatively high cross-referencing of the main author groups in institutional theory. For example, 6 papers cite DiMaggio and Powell, Zucker, Scott as well as Granovetter, suggesting an effort to span a range of institutional perspectives. Of the seven (7) papers which considered more detailed perspectives of theorists not included in the core group for the analysis, these include: Bourdieu (Franssen and Kuipers, 2013; Luc et al, 2008); Latour and Orlikowsky (Bridgman and Willmott, 2009) as well as Ferner and Drucker (Boussebaa, 2006).

Despite limited references to Ostrom in the study set (6 papers refer to Ostrom's work), the term 'collectives' appears as one of the most prominent terms explored across the study set with 52% (39) papers referencing the term. However, no articles mentioned or extended their perspectives to DiMaggio and Powell's 'collective rationality.' The only paper captured in the search which referred to collective rationality was by Baxter and Lambert (1991), which fell outside the study period, but was reviewed as an anomaly.

Bourdieu was cross-referenced in a way that emphasised his broad conceptual alignment with neo-institutionalism (which concurs with Martin, 2003). However, most papers provided only cursory references, briefly noting Bourdieu's concepts of social capital theory (Hazen et al, 2016; Ko and Liu, 2017) or agency (Dacin, Dacin and Tracey, 2011). Luk et al (2008) looked at Bourdieu's social capital in alternate contexts, by comparing social values of 'informal guanxi' over formal institutional rules which imply a value as 'intellectual capital.'

Franssen and Kuipers (2013) also looked in more detail at Bourdieu's field theory in studying the expertise and networks of literary editors. While noting the close alignment with neo-institutional theory, they describe the wider field of 'cultural production' in more agent-like terms. For example, they ascribe editors with a "feel for the game", when describing an emerging tension between participating in the global field (of literary publishing) and competing within it (Franssen and Kuipers, 2013, p.41). Modell et al also considered Bourdieu in relation to science communities in terms of their "… institutionalised beliefs and practices, or *doxa*" (Modell et al., 2016, p.75) in a way that is also directly relevant to this research.

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[16] A 'substantive' reference was considered where papers made three or more in text references to a key author/source. There were numerous papers where only a single, passing reference was made to institutional theorists.

4.2.2   Searching for networks in the literature – clusters and polarities

As noted previously, no papers referred to the field of 'network science' as a topic in the subset identified in the Web of Science search. In the subset reviewed, only two papers were identified which referred to the work by Watts and Strogatz (1999). Similarly, Granovetter's work, which was cited by 29% of papers in the study set, had no real substantive references. For example, the study by Franssen and Kuipers (2013) doesn't reference Granovetter, although it is very similar to Uzzi's work in tracing interconnections in the field, which was based on Granovetter's strength of weak ties (1973). However, a study on systems biology by Styhre (2011) draws on Granovetter's later work to counter his concerns of the "undersocialized" work of science (Granovetter, 1983), by considering 'the researcher' in more detail.

More subtle aspects of polarities and 'drifts' may not be noticed through word frequency alone. A second stage analysis looked at cluster analysis across the study sets. This was conducted in NVIVO using the Pearson Correlation 'in the box' analysis to identify a similarity index based on semantic similarity between pairs of papers. Two levels of cluster analysis were performed. One within the set – i.e. to identify similar papers within the study set and secondly, between sets, to compare the study set with the other sets of literature. A further analysis of *between* set similarity identified papers most closely related to foundational or review papers.

A set of the most closely related papers *within* the study set were identified and then explored in more detail. While the cluster analysis highlights possible related papers, a closer reading is required to determine what similarities have relevance. The six papers with highest within set proximity of between 0.83 and 0.7, but least proximity to the institutional theory set were considered for further review. A summary of commonalities between this cluster of papers is shown in Table 4.1. A visualisation of the cluster analysis output is shown in Appendix VI.

This cluster helped identify the common use of mathematical sociology as a key methodology in network-like studies referring to institutional theory. Commonalities and fields of focus are noted in the table, for example all papers cited Meyer and Rowan (1977) and five papers briefly refer to isomorphism as an element in interpreting their findings. Younkin (2016) and Jaquette (2013) both consider abandonment and adoption of practice in terms of network theory – as linking and loss of links between entities. Balachandran (2018) conceptualises the links between entities across institutional boundaries at a macro level while Fiss, Kennedy and Davis (2012) consider networks at a microlevel.

The **between** study set analysis, effectively found papers which aligned relatively closely to other neo-institutional works. These included Davis and Marquis (2005) and Sellers, Fogarty and Parker (2012) as papers of relevance for their breadth. Although references to DiMaggio and Granovetter returned a high word frequency across the study set, the cluster analysis suggests an overall deeper alignment with more recent interpretations of neo-institutionalism by Scott (2014).

Other closely 'clustered' papers identified a link in addressing complexity. Luo, Koput and Powell (2009), similarly apply an analysis based on Bonacich, but also cite Watts. Nilashi et al (2016) and Teo et al (2003) consider both complexity and coercive effects by similarly applying DiMaggio and Powell's isomorphic pressures and also consider diffusion and adoption. Work by Oehme and Bort (2015) on biotechnology SMEs seemed to fit within both clusters. Their work similarly considered legitimacy and isomorphism, as well as centrality, but their findings demonstrate interesting systems effects.

Paper / Focus	Zhou and Delios (2010)	Jaquette (2013)	Fiss, Kennedy & Davis (2012)	Balachandran and Hernandez (2018)	Younkin (2016)	Oehme and Bort (2015)
Context	Institutional and network factors affecting listed firms in China	Universities & liberal arts colleges in the US	Corporate contracting in the US	Innovation in interorganizational networks	Fortune 500 companies analysis	Biotechnology SMEs in Germany
Interconnection of entities	listed firms	University-college relationships	contract provisions (artefacts)	interfirm networks	intrafirm practices	inter-organisational networks
Empirical focus	Listed Firms – stock market data	US Colleges & Universities data	Golden parachute agreements	Global network of biotechnology alliances	Analysis of decommitment + document analysis	Historic review, Registry data and encoded documents
Macro/Institutional environment	Government and corporations	The Higher Education system and the market	The corporation	Global alliances	The corporate environment	National policy, research and development system
DiMaggio and Powell reference	isomorphism	isomorphism	isomorphism	No	isomorphism; institutional pressure	isomorphism
Meyer and Rowan reference	"a firm's embeddedness in a social context can affect its strategy formulation & implementation."	"organizations in strong institutional environments [resist] change, even in adverse … conditions"	institutional environment & knowledge	institutional environment & knowledge	"… adoption of elements of a practice to meet external expectations"	isomorphism
Other institutional theory sources	Scott, North	Selznick, Greenwood and Hinings	Scott, Czarniawaska Tolbert & Zucker.	North (1990) Scott (1995) Selznick	Davis et al (1994) Selznick	Davis (1991) Granovetter (1985)
Network methods / theory	Yes (after Mizruchi & Galaskiewicz, 1994)	Davis (1991) – Contagion Kraatz (1998) – network ties	Yes – Bonacich centrality	Yes – Johnson's (1967) hierarchy clustering algorithm & Bonacich centrality	Yes – Entropy Score (Davis et al, 1994)	Yes – Bonacich centrality. Abrahamson & Rosenkopf (1997)
Diffusion of practices / strategies	Yes (after Greve, 1998)	Yes (after Mizruchi, 1994)	Yes (after Lounsbury, 2001)	No	Yes (after Fiss and Zajac, 2004; Marquis and Lounsbury, 2007)	Yes (after Abrahamson and Rosenkopf, 1997 and Greve, 1995)

4.2.3   Interpretation of findings

The findings affirm minimal intersection by contemporary scholars with DiMaggio and Powell's intended perspective on networks in relation to institutional theory (DiMaggio, 1995; Greenwood and Meyer, 2008). Table 4.4 below provides an overview of the institutional and network focus across the key papers identified in the analysis of the literature. In relation to the approach to networks in the studies, authors were most likely to draw on methods established in mathematical sociology. As noted in Chapter 2, key authors in this field, including Phillip Bonacich, lay a claim to the field of the 'sociology of networks' (Bonacich, 2008). This field also provides an established body of work and a set of methods which researchers, with a focus on quantitative empirical approaches, were seen to follow in relation to organisational studies.

One paper in the integrative review study set cited both Bonacich and Watts (Henriksen and Seabrooke, 2016), signalling an effort to link these fields. However, the findings suggest authors who reference both institutional theory and network characteristics draw on DiMaggio and Powell's 'isomorphism' and Bonacich's 'centrality' as factors – among others - within wider multifactorial analysis studies. Although there were studies which considered complex environments, such as Oehme and Bort (2016), the underlying potential to progress institutional theory may be rather limited by these approaches.

Despite calls for further attention to different forms of organising (Meyer and Höllerer, 2014), there remains an apparent focus on relating institutional theory to the problematised postmillennial organisation as noted by Davis and Marquis (2005). Suggested challenges to more holistic adoption of neo-institutionalism may include 'isomorphism' as DiMaggio and Powell's prominent thesis (as noted in Chapter 2). Also, neo-institutional theory's consideration of networks and suggestion of 'mindless cognition' has not been acceptable to more recent proponents of institutional logics (Thornton et al, 2012).

Ironically, the methodical work of the three pillars framework to support interpretation of neo-institutional theory by Scott (2004), may also result in more structuralist approaches. As Greenwood and Meyer note, Scott's classification provides "… the now-standard formulation … in doing so, Scott effectively institutionalized the classification itself" (Greenwood and Meyer, 2008, p. 262). This view is represented in the cluster analysis with the relatively high similarity to Scott's work of those papers applying DiMaggio and Powell's isomorphism to their studies.

In relation to networks, the gap between institutional theory and network science, may be simply a selection of tools. Until 2008, when Bonacich reviewed the book by Watts,

Newman and Barabási on 'new' network science, the two fields were not connected to each other. However, there are potential benefits in 'reconnecting the social', as Watts attends to (Watts, 2004). Burt's summary of the work of Bonacich and others, which extends from theoretical economics to social psychology and behavioural sciences, notes that even its authors find mathematical sociology "... a difficult field to define" (Burt, 2010, p. 162).

Mathematical sociology also has theoretical credence. Although Burt notes mathematical sociology only touches on probability, the field aims to address dynamic and complex cases, noting engagement with "…space and time, participating in a complex structure of social activities" (Burt, 2010, p. 163). As Bonacich (2008) acknowledges in his review of the work of Watts and others, there are also new fields described in network science which had not been considered at that point in mathematical sociology. In the world of Barabási's and Kleinberg's network science, probability and paradox become part of the strange story of network behaviour. This provides an interesting prospect for considering networks and the application of institutional theory to provide further insights into complex systems.

4.3 The research professional - Tapping perspectives from the field

The role of the 'professions' in forming the institutional field was another area of focus for neointitutional theory. The professions are seen as important actors who "… construct around themselves an environment that constrains their ability to change further in later years" (DiMaggio and Powell, 1983, p. 148). The emergence of the global 'research profession' is evident from the formation of associations, such as the Australian Research Management Society in 1999[17] and the International Network of Research Management Societies in 2001[18]. The research profession was selected for the study given their potential view into the institution in relation to research management itself, but also for their broader involvement with formation of Research Centres and/or new research networks.

Lindquist (1999) considered similar roles in Higher Education through the American Institutional Researchers Association (AIRA) over three consecutive surveys: 1981, 1994 and 1998 and noted some relevant trends. Notably, the increasing number of women entering the profession and a shift toward research design and analysis in the 1990s. Initially roles in HEI research focussed on student matters, such as enrolments and retention. By 1998, accountability, information systems and data management became priorities (Lindquist, 1999).

The first international Research Administration as a Profession (RAAAP) survey conducted in 2016 defines the research profession broadly as those involved in "… the leadership, management or support of research activities" (Kerridge and Scott, 2018, p.2 after Beasley). The interim results of a further RAAAP survey in 2019 (INORMS, 2019) also highlights the predominance of women in the profession (78% at managerial level) and the very high proportion (28%) of research professionals who hold PhD qualifications (n=4325).

While these studies provide a valuable baseline on the research profession demographic and deployment, they do not consider the profession in more depth at this stage. Further work is currently addressing this "hidden community of professionals" by proposing the term: 'professionals at the interface of science' to represent their diverse contributions across the science landscape (Santos, Varela and Kerridge, 2021, p.4)

As noted in Chapter 3, bringing together an expert group via the INORMS International Congress in 2018 offered an opportunity to tap their expertise. The focus group session explored three main areas: the types of interactions research professionals engaged in, including the types of groupings participants identified interacting with; the

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awareness of the group of network analysis tools in considering their interactions and thirdly their perceptions of the Higher Education Institution in relation to a Research Centre and the potential for wider research engagement.

4.3.1 The focus group profile

The eighteen (18) participants who took part in the interactive focus group session represented international experience of engagement across the research profession. Twelve (12) were based in Europe, including representatives from across the UK, and 6 were working in Southern Hemisphere institutions: including representatives from Australia, New Zealand, South Africa and Singapore.

The participants were also a highly experienced group in the field of research management with 3 participants working at Director or Senior advisor level, 13 working at Manager level and a further 2 working in more administrative roles. I estimated the gender ratio to be 0.4:1 men:women.[19]

Of the 13 participants who completed the pilot survey, eight (8) held roles within the HEI's administration with most acting in HEI Executive or Central Administration roles (5). The remainder held roles outside the HE System, one in a government research agency, one in a partner (non-HEI) research organisation and 3 others were based in dedicated research centres.

Although the main purpose of the survey was to test a range of potential questions for further exploration in the empirical study, these profiles indicate that the contributors to the session provided a valuable level of expertise as well covering a high level of international experience. The pilot survey responses also indicated an opportunity to gather both internal as well as external perspectives of research centres and networks in relation to the HEI.

4.3.2 Interactions analysis

As outlined in Chapter 3, the core focus group activity asked participants to produce up to five work-based interactions each. Overall this provided 80 interactions for the analysis. Participants were asked to select a three-month period when recording their interactions and to note the reason for selecting this period, as well as briefly summarising what the main purpose of the interactions were over this time.

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[19] Participants were not asked to provide data on their gender and this is only based on observation by the researcher.

A summary of the main activity identified is summarised in Table 4.2 below. Those responses which related to a 'busy period' of interactions are highlighted in blue. Of value to note was the majority linked specific activity to researcher interactions (29%), followed by interactions with the Core HEI (20%). This suggests a true Janus-like split in activity. 'Other' interactions included HR related functions, such as job interviews and professional development. While interaction descriptions allocated to 'other HEIs' were very low (2%), on closer review a number of descriptions allocated to 'other' (16%) included interactions with both other HEIs and partner organisations.

Table 4.2 Participant profile and description of main purpose of interactions over the period chosen

Role Type	General Activity	Specific Activity	Compound Activities
Officer/ Administration (3)		Training and feedback To improve communications across the team and researchers	Networking, setting up processes in new role
Manager (10)	Core part of job Work-related Business as usual Research support	New and ongoing initiatives Staff management and development Funding applications	General very busy managing funds and external bids and firefighting Most often REF preparation and supporting practice researchers Various - bids, centre management, team management
Advisor/ Director (5)		Relocating the role of research centres under the school	Varied selecting candidates, training, management, organisation

By allocating the interactions based on their descriptions as either an internal interaction – ie within the HEI (assuming all researchers referred to were internal), the overall interaction profile provided was estimated as being 65% internal and 35% external.

The suggestion by the participants to view interactions by scale. For example, one:one, allowed the whole set of 80 interactions to be reviewed to refresh the view of the data. This was relatively straightforward given the interaction descriptions. This analysis indicated almost half (46%) of the interactions were with groups, while 33% were 1:1 interactions. The remainder, 21%, were categorised by the participants as 'general transmit communications.' The interactions suggest a relatively high level of interactions with groups. However one-to-one interactions with researchers was noted as high, suggesting important engagement between research professionals and academics. Also of note were the range of researcher roles recorded in the interaction descriptions, suggesting research managers act as significant contact points across academic groupings.

In similar work by Holmen et al (2013, p.143) amalgamated interactions were scaled by the order of the network from single (actor) view, one-to-one interactions, 1-many

and then ordered by internal vs external interactions. These are very similar to how the research professionals engaged in the focus group spontaneously grouped their interactions.

Exploration of the interactions set – which was transposed from the post-its to Excel and then imported into NVIVO – identified a high use of the term 'new.' This appeared in 18/80 interaction notes. A review of related phrases indicates a relatively high level of commitment to leading 'new' initiatives as well as the orientation of 'new' staff members. These provide examples of the research professional as a varied role which supports institutional capacity as well as directly enabling researchers.

4.3.4 Focus Group Survey Analysis

Thirteen (13) Focus Group participants responded to the Focus Group survey. Of these, twelve (12) responses were suitable for analysis. Responses of value to the profile questions were those that clearly distinguished roles and level of experience in relation to Research Centre development. The first distinguished those who considered their role within the core administration or faculty role to those in a Research Centre or in a non-HEI role.

Respondents were most likely to have had roles or experience associated with either the 'startup' or 'operational' phase of a Research Centre, with only one respondent indicating a high level of experience in scaling down or closing a Research Centre. This indicates that, despite the small group size, a breadth of experience was present in the Focus Group session.

The survey included two questions with preassigned interaction groupings. These were; 'within institutional groupings', such as grant administration and 'external groupings', such as other HEIs. Participants were asked to indicate 'frequency of interaction' for internal interactions and to rate 'significance of interactions' for a set of external groups (assuming frequency would be lower with this group). The internal interactions frequency data was relatively well separated – with resourcing and grant administration being the most frequent sites of interaction.

The significance of external interactions is less clear, with most participants rating each option similarly. However, overall interactions 'closer' to the institution were higher, for example interactions with regional governments were more important than those at distance, such as national government and international researchers. Interestingly, interactions with domestic researchers in other HEIs was rated as relatively significant and

this contributed to an overall picture of high engagement with researchers at a more local level.

This suggests research professions, although highly internationalised, may not (or perhaps cannot) place a high priority on more extensive engagement and suggests relevance when considering network effects in research development.

4.3.5   Semantic question set findings

The focus group survey also included a set of five semantic questions which linked to the Janus model. These proposed possible dualisms to gain a view of the potential for this type of questions to be valuable in capturing indicative perceptions of the HEI and Research Centre environment. Participants were asked to consider the questions from the perspective of a Research Centre they were engaged with and to consider the Centre as a whole in responding to these questions. Although the questions were based on institutional theory, all had potential to be considered as indicators of a perception of 'institutional distance' in a network sense.

For example, in relation to legitimacy the question was: *In terms of the Research Centre's potential to interact independently with other organisations would you consider the Centre to be: 1 = Highly independent from the HEI => 5 = Highly Dependent on the HEI.*

Notably, no respondents rated the Research Centre as highly independent of the HEI. The second question, which asked a similar question related to independence, but with a subtle aspect, looked for perceptions of embeddedness of the Research Centre within the institution[20].

In terms of the HEI role in supporting the Research Centre overall, do you consider: 1 = The HEI provides a home for the Research Centre => 5 The HEI acts as a Host for the Research Centre. Interestingly, although the survey noted relatively lower responses to international engagement, most respondents were likely to 'see the Research Centre' as predominantly globally facing. A summary of the responses is shown in Table 4.3 below.

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[20] These questions were complemented by a conversation with Jonathon Stagg whose work looked at the establishment of five major research institutes in Queensland. He noted that some academics described the university as a 'home' for the institutes, while others saw 'their' institutes as highly independent entities.

Table 4.3 Focus group responses to semantic question set

Indicator	More like this						More like this
Legitimacy	Independent	0%	33%	17%	33%	17%	**Dependent**
Embeddedness	HEI is a Home	17%	42%	8%	25%	8%	HEI is a Host
Autonomy	**Responsive**	17%	**50%**	25%	8%	0%	Constrained
Adaptability	**Creative**	25%	42%	8%	17%	8%	Systematic
Orientation	**Global**	33%	33%	25%	8%	0%	Local

Statistical considerations for transforming semantic questions to ordinals for analysis followed work by Lalla (2017). The data was also explored statistically for value to apply to the CoE study. The purpose of this analysis was to determine to what extent respondents could distinguish the potential polarity or duality intended by the question design. Based on the analysis of the semantic questions for the Focus Group, each was reviewed and some revised for use as a pre-interview survey for the CoE study. While the findings suggested value in retaining an approach which used semantic questions as interview prompts, there was potential to make some terms clearer and more neutral. For example, in the question on adaptability, the response terms were changed to 'flexible' instead of 'creative' and 'strategic' instead of 'systematic.'

4.3.6 Informing the next stage

Despite some constraints in running the Focus Group within a conference setting, the participants and their contributions greatly supported development of the CoE study. In addition to the activities, the session demonstrated research professionals enjoy a common language and were readily able to participate and respond to questions in a short time frame. Of note was one participant from a library systems role who wasn't able to readily respond to the pre-interview survey questions. This suggests the self-selecting group for the session shared very similar perspectives based on their professional grouping rather than their institutional location.

The relatively high levels of direct interactions between Research Managers with researchers both from within their own institution, as well as with those in (national) partner institutions, were important findings. This information suggests that the professional group are not only active brokers of relationships and support for research development but also that these roles are increasingly inter-related within and across institutions. The output of

the INORMS Focus Group indicated realistic potential in exploring the institutional interactions and network-making role by research professionals in more detail. However, the relatively high interactions with researchers suggested that both research professionals and researchers should be considered together as a potential synergistic pairing in understanding research network development.

4.4 Changing perspectives – the Centre of Excellence as a Janus

4.4.1 Introduction to the CoE Study findings

I approached the study with the assumption that Centres of Excellence (CoEs) could act as a Janus object to simultaneously 'view' the institutional and the network environments. This starting point aimed to capture a 'big picture view.' The Research and Professional Leads approached to contribute to the study were considered well placed to provide both a wider perspective and a detailed experience of the institutional environment.

Based on the close engagement of researchers and research professionals identified in the INORMS Focus Group findings, the paired perspectives of Research Lead (RL) and Professional Lead (PL) came into focus. This allowed for a holistic view of this complex system. As discussed in the literature review, studies on Research Centres which consider the relative value of these organisational forms, typically focus on the role of researchers. If two potentially highly interrelated roles were looking out from the Centre, could we learn from different perspectives?

As noted in Chapter 3, the approach to the analysis explored emergent themes in the narratives which I present here. In this overview of findings, I mainly follow an institutional perspective. In Chapter 5, I consider a further synthesis by introducing a network perspective.

I start briefly with a profile of the interviewees and introduce their contributions as CoE Co-Leads. Firstly, I describe the role titles and the relationship between the RL and the PL roles. Based on the lively narratives I describe the pair as a potential 'Dynamic Duo.' In particular five (5) RL-PL leads demonstrated this type of shared energy. The amusing (albeit sobering) tale of 'the ARC bus' highlights some of the personal positives, as well as risks,

described in taking on the role of leading a CoE. Here I focus on the 'origin stories' and the early formation of the CoE.

Next, I give an overview from the PL perspective. One PL summed up a closely shared experience as: 'I was Employee number 1.' Although some PLs arrived later in the life of the CoE, many describe their experience as the first formal CoE 'employee', whose first focus is typically to translate the 'CoE plans set out in the submission and, upon funding, the formal partnership agreement, into an operational state. I close off the section by presenting the 'dynamic duo' cases which describe 'enacting' a next iteration CoE.

The next section focuses on the 'Chief Investigators' as a collective in forming the nidus of the CoE. As one RL describes their role as both a lead and a co Chief Investigator, 'as a lead violinist … playing within a [chamber] orchestra.' I first look at the layered descriptions of the CI group; from how researchers self-organise as prospective Chief Investigators (CIs), to then re-organise to bring a substantial, fully funded research programme to life. By exploring 115 statements from the interviews relating to the CI role, I look at how the CI role constitutes the CoE through a series of origin stories.

I follow on to consider some of the tensions noted in maintaining engagement of CIs in the CoE. One particular quote: 'What does [the Director] say? They're off the reservation?' This provides a perspective of how CIs can, at times, test expectations of formation and, potentially formalisation, of the CoE. I balance this view of 'wrangling' CIs to those statements which highlight the lead roles, particularly of individual CIs, which recognise both the CI 'reach' beyond the CoE and the challenge in balancing their contribution to the CoE.

Another emerging theme related to views of the 'researcher collective.' These views were a mix of influences and engagement practices which could then shepherd the CoE in particular ways. In this section: 'The Centre is greater than its parts', I highlight descriptions which relate to CoE groupings which describe activity, coherence and arrival at a sense of the Gestalt. Here I provide a view of the CoE as a 'bubbling' form, as described by the participants and note how science discovery itself is described as an actor in the system.

The following section considers more directly how the CoE interplays within the HEI and the wider institutional environment. Here the cultural aspects of research activity and its potential to impact on the institution are prominent, as noted by the quote: 'If the VC knew where we were it would be a miracle.' This summarises an apparent paradox shared by a number of participants of efforts to work within a perceived 'ambivalent' HEI environment. While noting both their dependence on and autonomy from the HEI, this

section considers how participants respond to how the CoE is seen (or not) in the institutional environment.

To counter this ambivalent view, I then look at ways the CoE 'works around' the institutional environment. This emerged through a particular theme encompassed by the quote: 'You wouldn't know half the human race was female.' This highlights a shared narrative where CoE policy-making aims to 'fill a gap' in an institutional policy vacuum.

This section also describes the potential for the 'CoE population' to have an effect on national research policy, particularly in relation to building research capacity.

4.4.2   The Dynamic Duo

The role titles used in the CoEs need a brief description. While there are a series of titles assigned to the CoE Programme, I want to assign generic terms for those in Research assigned roles and those in Professional assigned roles. For ease of setting out the findings and analysis that follows in Chapter 5, I have used working terms as 'Research Leads (RLs)' and 'Professional Leads (PL)'. In the quotes throughout I also notate whether these are from "RLs" or "PLs."

Research Leads are those participants who are mainly engaged in research development through oversight of research strategy, opportunity and delivery; these include roles such as Centre Directors, Node Leaders, Portfolio Leads and Chief Investigators.

Professional Leads may include titles such as; Chief Operating Officers (COOs), Centre Managers etc., who are mainly engaged in research administration, the 'whole of Centre' operation and accountability functions. Of course, both roles do far more.

However, the role titles don't match the reality. Centre Directors in particular were keen to emphasise, their role was far more 'facilitator' then 'director'. A number made it clear they had no ability or remit to 'direct' anyone, although they clearly described ways they lead through delegation and engagement. COOs too often emphasised this paucity of institutional power on behalf of their Directors. They also noted the slight misnomer of the COO title in relation to the institution, noting '…there is only one COO at the HEI.'

Of interest too was the overlay and potential synergy of these roles, particularly from the pairs of interviewees (e.g. Centre Directors and COOs from the same CoE). Some of these pairs were in the process of navigating a further iteration of a CoE. A profile of the participants is shown in Figure 4.1 below
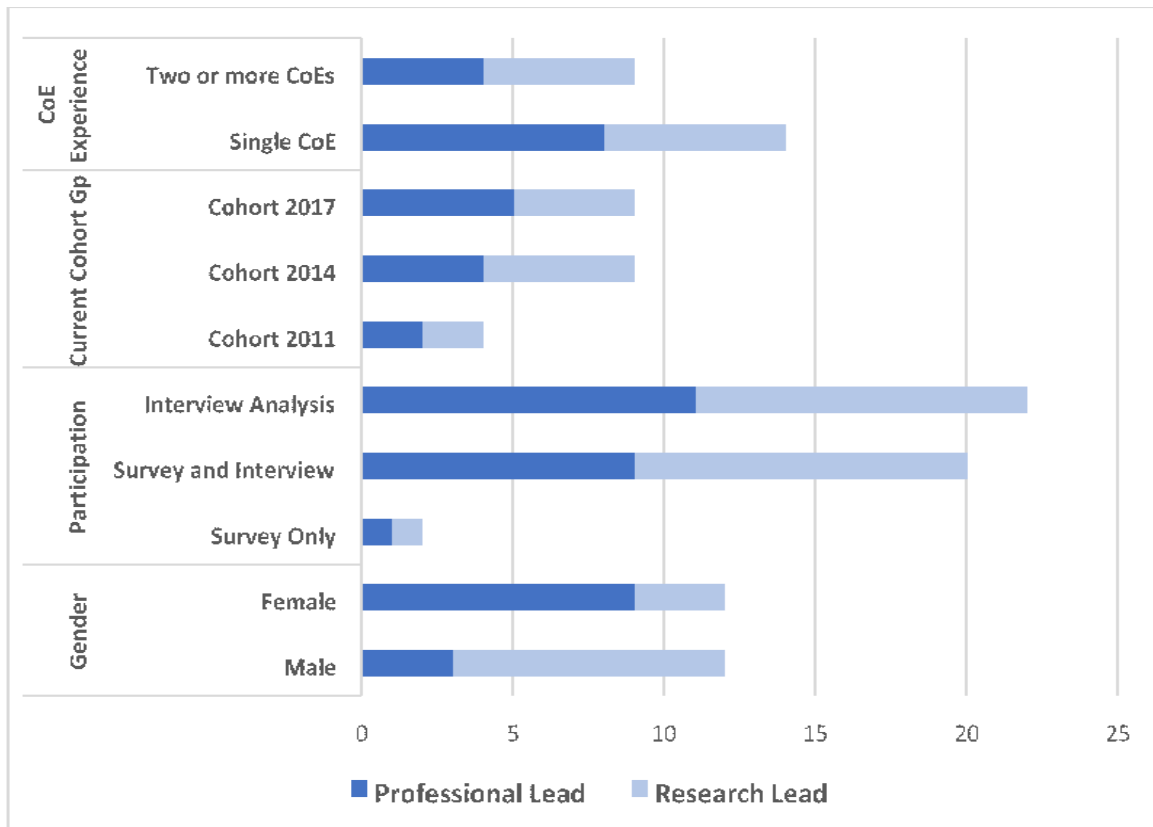
4.4.3   Research Leads and "The ARC Bus"

An anecdote about the ARC Bus – *"…I said, 'If I'd know there was a fucking death toll I would have negotiated harder before I took the job' …"* was a frank telling about taking on the mantle of leading a CoE. More than one participant shared similar stories about the 'ARC Bus', particularly in relation to their personal experiences in the early stages of the CoE's development. The closure of a CoE could also take a personal toll.

Those coming in new to lead a CoE conveyed a sense that nothing could fully prepare them for the role. When asked about their previous experience in relation to the Centre Director role, at least two interviewees stated their prior experience in institutional leadership roles was *'… nothing like leading a CoE.'*

Even those who had been Directors of earlier CoEs were keen to emphasise that the next iteration of any CoE was a new challenge in its own right. One interviewee described it in terms of an Olympic competition:

'…If you're good enough to win the gold medal in the 2000 Olympics then you set that as your standard, you're stuffed when you hit the, whenever the next Olympics is, and it's the same with the CoEs.' RL11

As noted in Figure 4.1 eight (8) interviewees had leadership experience in at least one earlier ARC Centre of Excellence and some were continuing in new iterations of a CoE in equivalent roles. Others had some prior experience in a CoE as a Chief Investigator or Deputy Director, allowing them to 'grow into' a Director role in a new CoE. In other cases, the leadership of a CoE was a completely new and novel experience.

One RL described being a 'very reluctant' leader who relented after colleagues exerted 'a bit of arm twisting.' Another took on the RL role after being approached by colleagues. Newcomers to leading a CoE proposal included one who galvanised others to support a bid and one who stepped into the role at the onset of the CoE when another lead stepped out. While some admitted to coming into the early process of participating in a CoE with little knowledge of the programme, two interviewees described having "… been doing it forever" – that is they had long-term experience of participating in the ARC CoE Programme.

4.4.4   Professional Lead stories: "I was Employee #1"

In contrast to the Research Leads, who usually describe their participation as part of "a longer gestation" in the overall project, five (5) of the Professional Leads interviewed describe arriving to the Centre around the point when a signed agreement was enacted by the HEI consortium. The structural constraint of the CoEs in appointing a role primarily tasked to operationalise the new Centre is described by one interviewee:

'… I came on board – I was kind of like **employee number one**. … I really came on board just as the agreements were being signed, and up until then they couldn't really do anything because they couldn't recruit and so they did take a risk and recruit my position.' PL19

While the PL may have knowledge of how the CoE was formed, only one PL gave an account of the conceptual development for a new CoE. In this case the PL participated in supporting the formal bid phase from an institutional 'proto-centre' and was subsequently appointed to the formalised CoE role. Apart from PLs who were now leading a 'second iteration CoE', most PLs did not have direct experience of this formative stage of the CoE.

This is also illustrated by the survey responses on participant experience in the conceptual stage of the current CoE or prior experience in an equivalent research programme. Figure 4.2 below shows that all the Research Leads who responded to the pre-

interview survey (11) were highly involved at the concept stage of the current CoE (y axis), and the majority also indicated a relatively high level of prior experience in similar research programmes (x axis). However Professional Leads were more likely to have limited to no engagement in the conceptual stage of the CoE in which they worked.
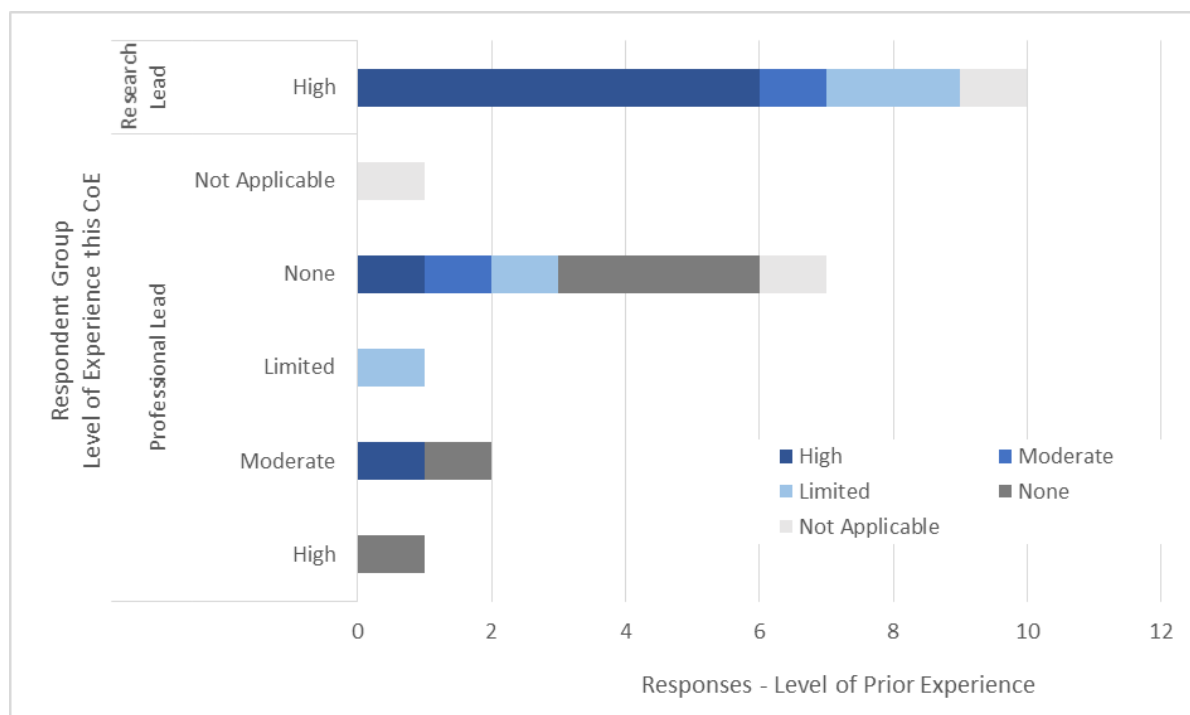
In the case of PLs, including those referring to 'their life' in an earlier CoE, most describe the 'start-up phase' as the point at which their appointment commenced. Interviewees related the breadth of their work in this start-up phase, from enacting governance arrangements under the agreement to establishing a visible entity with a set of functions, relationships and activities. The self-described actions provided indicate a balance even at an early stage between the operational design role and the cultural and relationship building role of bringing the research group together. For example, PLs described two key aspects during the start-up period; firstly, in establishing formal processes :

'… [I] was very instrumental in starting - designing all the processes, governance all that kind of stuff' PL5.

And secondly, through enabling the development of relationships, establishing networks and culture through the layers of the CoE:

'…building those relationships amongst, first the senior people, then moving down into the … mid careers and then the students' PL7.

Although a number of PLs indicated limited experience in leading the operations of a research programme prior to their appointment in a CoE, a number of respondents had backgrounds in start-up environments or had prior institutional experience, such as in HR or in research management roles that supported 'start-up' priorities, such as recruitment and systems implementation.

4.4.5   Synergies and evolving roles

The pre-interview survey asked a series of semantic questions about participant perceptions of the CoE in relation to the lead Higher Education Institution (HEI) and the wider research environment. As noted earlier, these were revised from the original set of questions asked in the INORMS focus group survey. The purpose of the questions was to provide prompts for further discussion rather than to identify any particular differences in responses between the groups – particularly given the small number of participants.

However, there were some interesting differences between the Research Lead and Professional Lead responses, notably in relation to the perceived dependence on the HEI. In the pre-interview survey Research Leads appear to place more emphasis on; dependence on the HEI, considered the HEI more of a 'home for', rather than as a 'host of' the CoE and slightly more likely to recognise HEI policy as relevant to the CoE's focus. Conversely, Professional Leads indicate more of a focus on the local, rather than the global. The subsequent interviews suggest a subtler interpretation of these questions and often a counter discussion took place. However, it appears that the two CoE leads (RL and PL) do take different perspectives in relation to the lead institution, particularly in terms of how they envisage the orientation of the CoE toward the HEI. A summary of responses to the pre-interview survey is shown in Table 4.4 in the following section.

Over the period of the cohorts studied (that is from 2011 – 2017 inclusively), the role of the PL was noted by a number of interviewees. In particular there was a sense that the PL role was being recognised as more pivotal to the CoE. Although some PLs interviews noted there may be a more 'traditional' CoLead relationship in some CoEs: "… some COOs just do what their Director tells them to …", the PLs who contributed to the interviews indicated a strong personal contribution to the CoE. RLs often emphasised the importance of the PL in their role as CoE 'knowledge holder.' As one Research Lead described:

"… All the success of the Centre is not on the Director, it's on the COO …" RL3.

Professional Leads in second iteration CoEs noted the changing nature of their role in terms of the 'co-evolution' of the CoE Programme. As one PL describes:

'… I came into the [first CoE] as not much more than a senior administrator. It was viewed that way by the Director and CIs and most in the Centre … Coming into the [second iteration CoE] really evolved … I was able to … have an actual seat at the table … in structural and strategic ideas, both at the proposal but envisaging what the Centre would actually look like' PL9.

This changing role might be translating into the PL backgrounds. As noted in the global trend in the research profession by Scott and Kerridge (2018), six (6) of the PL interviewees were postdoctoral researchers and five held PhDs in fields closely connected to the field of science of the CoE.

Some PLs noted that this research background supported engagement with the academic group, for example:

'…I had some publications in [the related field] … so that had some [importance] in a role such as this, to have the link with CIs, which is always crucial I think' PL10.

PLs also described wider network activities. This extended from contributions to ARC committees to active contributions to development of the wider research community of the CoE. In some cases this extended to support for amateur science communities with the field of the CoE.

Defining the PI role was also described as a key component in 'getting the CoE right.'

'… I was reflecting on this … because … I was in a selection panel shortlisting for a PL of another CoE and we were trying to think about what were the really important qualities you looked for?' RL20

Nevertheless, the business skills necessary for enactment of the Centre were described as important by the Research Leads:

'…Academics are not trained in management, right? There's a science to it and they don't teach it to us and most of us don't pick up and book and learn it. And [the COO has] been amazing - so any successes that the Centre has had I can really lay at the feet of the COO' RL11.

However, there was also some tension within the PL group in relation to their role 'type'. For those with a business background there was less interest in the PL role as an

institutional career path. Even for those with an institutional background there was a strong view that the PL role was not 'research management' in the institutional sense. For example,

'…Rather than [seeing the PL role] as research management, now we have a structure of 'network as influence' model' PL15.

There could be an irony here that while the PL roles are being shaped to be more network-like, as we shall see in the next section, there are proposals to make the research lead roles more institutionalised.

4.4.6 Legacy and dissipation of the CoE

While CoE origins give insight into the early configuration and development of the Centre, interviewees also described legacy stories of the CoEs. A number of contributors had either stepped out of the CoE or were close to leaving at the time of being interviewed and were able to provide a reflective account. Others were able to compare the transition to a new iteration of a CoE based on the lessons learned from a previous CoE. Those coming in new to a CoE were able to relate how they saw the contribution of the CoE to date or how they saw the CoE's future legacy.

As PLs are often not only the first person 'hired' by the CoE in start-up mode, sometimes, after seven or more years of personal investment, they are also the ones left to tie up the loose ends and then switch off the lights. As such their insights are of particular value for this phase of the CoE.

'… So, look, - I think that was a bit hard. But otherwise, no I think we had it quite well planned - and then we just started to stop doing things … then you get to the end of the to-do list and then give it to the final person and walk away.' PL5.

Perhaps because the PL, as an 'employee of the Centre', is subject to an absolute change at the close of the Centre, ie they no longer have a role at the close of the CoE (even in the university), the PLs may also bear more of the emotional separation from the CoE at its close. Meanwhile the RLs will typically fold back into their role in the institution. This disparity was expressed as a concern by one RL:

'… more than 80% of our budget goes on Postdocs and the admin are added people and finding longer [post-CoE] trajectories for them is the real issue' RL17.

One value was the observation of PLs of the 'drift' of research participants, including the CIs, back toward the institution as the CoE closes. They also note that the cessation of incentives may cause interdisciplinarity to wane.

'… at this point [toward the end of the funding of the Centre] they're starting to focus back … into their local teams. So I guess because those [Centre] schemes

are no longer running … those groups are probably … much more focussed back on … their [own fields of] expertise' PL8.

Also, the 'networking potential' which the CoE has worked so hard to develop is the aspect which falls away:

'… And what everybody wants you to have is a legacy by which what you've created by way of networking capacity can be sustained beyond the Centre and that is virtually impossible because people fall back into their institutional homes for obvious reasons. - And I think that is something a lot of CoEs are challenged by' RL6.

There are also some natural themes around temporality and transience of the CoEs alongside the concept of the CoE itself as 'a transitive entity' as anticipated in the consideration of potential ontologies for the CoE. One example of this sense of transience and loss of identity established over the life of the CoE was described as:

'… But you know unless they can find something else to kind of hand that brand over to … the entity in its own right - will kind of just disappear' PL19.

The value of legacy stories is not only to capture ways participants viewed, and sometimes 'counted' the outputs and impact of the CoE as a type of measurable legacy, but also to recognise how they related the practicalities and complexities of closing or negotiating and transitioning from one CoE to the next iteration.

The CoE legacy was noted as particularly important. In particular, 'policy legacies' and more broad views of 'changing the way a particular science is done' were highlighted by one interviewee as evidence of the growing "maturity" of the CoE Programme as a whole.

4.4.7   Engaging the CIs: "What does he say? They're off the reservation"

Narratives provided a detailed overview of the important role of the Chief Investigator (CI) group. The CoE forms through the contributions of a number of researchers, most of whom will go on to establish the CoE's Chief Investigator grouping. Other CIs may then be brought in to 'fit' the research programme. Once established as a 'CI group', individual CIs may be differentiated into particular lead roles and subgroups which act to contribute to decision-making on the science, support the overall capacity of te CoE - particularly in terms of the development of early career researchers - as well as inform the CoE's strategic direction and operational approaches.

In network terms, this group forms the first layer of the CoE, which is both loosely connected and then formally constituted through legal agreements with the CoE's partner

organisations. Over time then, the CIs have potential to engage closely with the Centre leadership and/or pursue more individual opportunities. This balance of academic leadership is explored here.

As noted in Chapter 3, because of the detail provided about the CIs an overview of statements relating to this group could be analysed in more detail. Through a process of considering emergent themes, the statements were identified into two main groups - firstly the 'Lead Role' and secondly 'Wrangling'. Figure 4.3 below shows the distribution of statements explored in relation to the participant groups and then gives seven (7) example statements which indicate a relationship to other factors of interest to the study model.

On the '*Wrangling*' side I considered three main groups of statements. The first, the *"herding cats"* group, tends to describe the character or personality of a researcher. Another statement *"we all have our problem children"* suggests a similar view of the researcher-at-large but with a more institutional layer. That is, these statements noted that the ways institutions 'work' might also have an effect on how CIs were operating or engaging with the CoE.

The last example includes the *"off the reservation"* statements. These statements suggest ways of approaching CI engagement such as by 'incentivising' or 'delegating.' In some cases, responses in these cases related to CoE policy – such as setting minimum contributions in FTE for CIs. For example:

'…I did set a minimum. I told them they couldn't be a CI below a certain fraction – I think I said it had to be 0.3 but we preferred 0.4 - 0.6. We actually have quite a high FTE contribution from lots of people.' RL21.

There was some weighting to the 'Wrangling' side, for example PLs were more likely to note concerns created by the occasional "rogue" CI. Although RLs also raised concerns, they refer to this in relation to concerns about the risk of the research endeavour becoming 'siloed'.

However, one pragmatic view suggests this 'behaviour' across a population of the CoE forms an inevitable part of the bigger picture.

'… you know in a big Centre - with 15 different CIs, then there's always going to be a couple who are going to take the money and run' PL10.

Similarly, for one recently formed CoE, there was a note of appreciation of the complexity in simply establishing the working environment for a CoE;

'… So, it's a very early Centre right … We brought in … 15 different people from across 5 different organisations, so it's going to take time' RL4.

In contrast to the **'Wrangling'** statements, the **'Lead Role'** statements illustrate both the outward role of the CIs as well as the institutional responsibilities CIs balance as part of their wider commitments. Generally, the RLs were more likely to describe CIs in relation to the Lead Role - this was weighted where RLs contributed 14 identifiable statements while PLs made 6 identifiable statements which most closely aligned with this theme.

The four example statements given here demonstrate how lead roles of CIs are viewed - firstly, in **international** leadership and capability CIs are recognised as highly mobile actors with national and global engagement points. Secondly in relation to **research capacity** – CIs are referred to as PhD Supervisors, line managers for Post-Doctoral research and mentors. However, they are also noted when they 'grow through a CoE role' to take on roles in the national research system, or as Deputies or other capacity building for the CoE directly. Thirdly, the CI role in **network-making** approaches was described in terms of nurturing and creating the culture of the CoE – in particular in supporting early career researcher engagement. Finally, CIs are recognised as wearers of *"many hats"*, particularly in the case of juggling their academic contribution and educational role, to their home institution.

These statements highlight the dynamic, mobile and diverse nature of the academic role which contributes to the culture and, perhaps relates to the 'personality' of the CoE. There is potentially a network-like consideration of how this dynamic relates to the overall cohesion of the CoE which is discussed in more detail in the following section.

Figure 4.3   References to Chief Investigators: example mapping by interaction type

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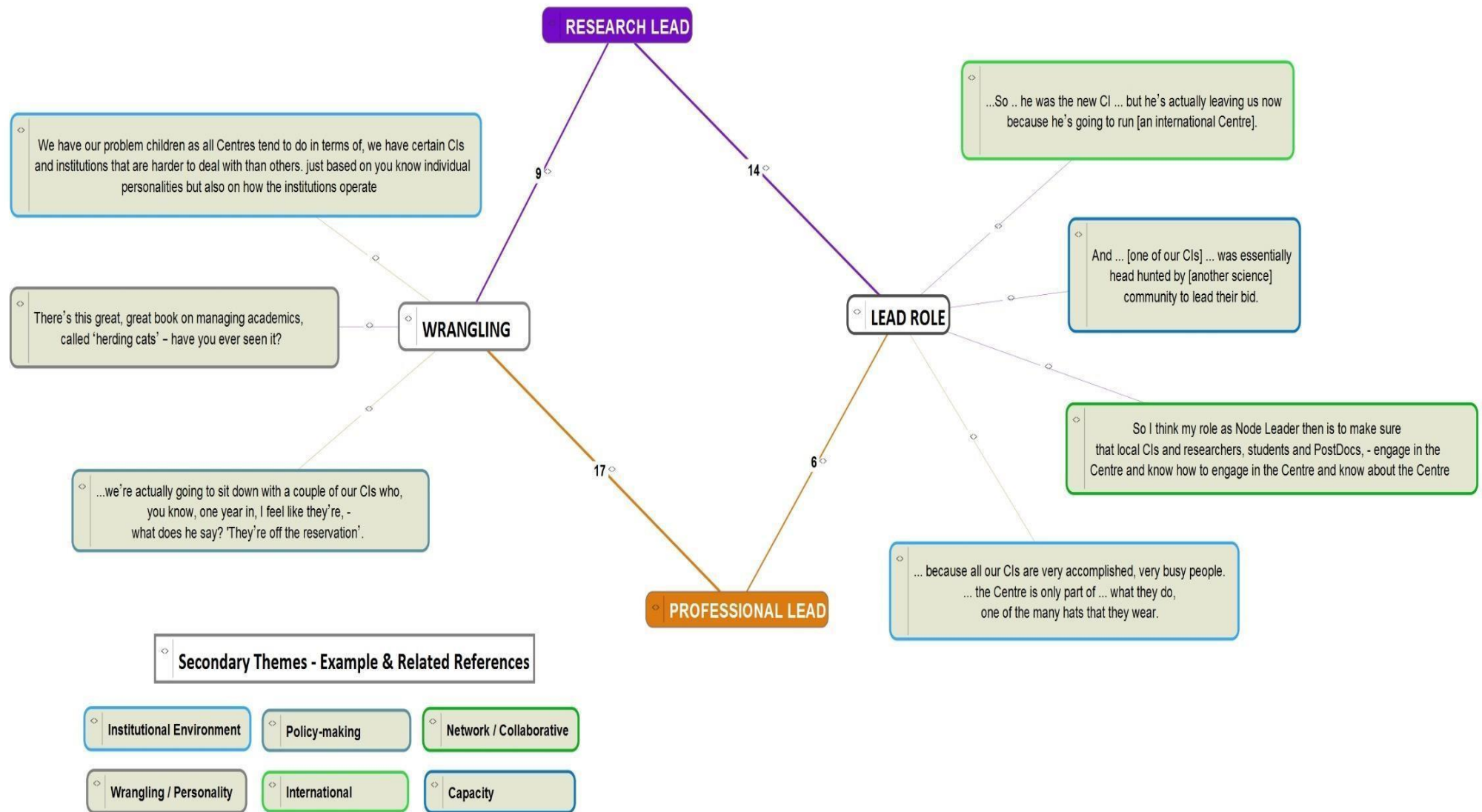
4.5 The Whole Centre

4.5.1 Configuring the Centre: "What is a team, right?"

"… are you thinking of a Centre as, like an octopus where you've got a head? - I don't think Centres work that way - we're more of a chess board"

A participant description of the Centre

The interview asked participants to 'walk out' from their own experience of interactions to those of a related CoE team. However, participants challenged the term 'team' and I modified my question to offer 'team' or 'groups.' In most cases participants 'grouped' people together at different layers across the CoE and a number referred to 'members' to describe how researchers engaged with the CoE. This is quite important in appreciating the organising perspective of the CoE as a relatively non-hierarchical process.

However, participants also clearly described the governance, decision making and operational structures enacted for the CoE. Across the transcripts references to the CoE 'executive' group appears fifty-nine (59) times, which demonstrates its high relevance as a starting point to describe the functional grouping of the CoE.

However, the executive could be constituted in numerous ways by the CoE – either as a cross cutting portfolio representation or as a node leader group. In other cases, the participants described 'whole of CoE meetings' rather than having a formal executive, which highlights flexibility to adopt an almost wholly network-like approach.

Reflections on restrictive governance were also noted:

'… We have the Executive Team, which is 8 CIs - and we have … secondary CIs at each of our institutions, who are not on the executive committee, and they're the ones that tend to get a little bit lost sometimes in our strategic thinking' PL10.

Narratives also provided a richer picture of the emergence of the CoE. These note the asynchronous nature of bringing new CIs on board, establishing roles in partner institutions, and even reconfiguring the CoE partner arrangements when key CIs move from one institution to the next. In this case the whole node can, at times, move with them. Of interest in this case is the apparent 'power' for the CoE to overcome formal institutional arrangements, even in the case of an individual researcher.

As noted earlier, role titles and participation in the executive groupings can change during the life of the Centre or be adjusted – 'improved on' in Centres in their next iteration. In one case the potential to further institutionalise the groupings was stated:

'… the idea of having Node Directors was not something we started with but something that developed over time, and [in] the new Centre we will institutionalise that more …' RL22.

4.5.2   The Cohesive Centre: "Greater than the Sum of its Parts."

"… We've been trying hard to get people to feel like they're part of something that's bigger than the university or just their teams and ... that's really important to get the Centre to work…"

Participant view of the CoE as 'a gestalt'

One of the 'rules' that I thought might apply in a relational sense was that a CoE could never be 'bigger' than the HEI. However, participants didn't see the CoE in these terms. In this response we see the CoE facing the field of science so that the CoE can be seen as part of something *'… bigger than the institution.'*

When interviewees were asked to 'step outside the CoE' and describe the whole, more network-like descriptions are apparent. One participant describes the design of the Centre roles and activities as '*interwoven nets',* which moves the Centre beyond the constraint of the earlier description of a '*chess board*', with its visible pieces 'on the table', to a far more diffuse entity.

Direct connections across the layers of the Centre were described alongside the more diffuse connections to students and postdocs, as well as associate and partner investigators. For example:

'… So, if I have a view of the whole centre then there's obviously our CIs, our Professors. As the programme managers across the organisation, they each have teams of anywhere from 1 – 4 [or] 5 postdocs and 1 – 6 to 7 [research] students' PL14.

The expansive nature of the CoE as a network extending beyond the institution was also highlighted in scale free terms:

'… So, this is what I kind of call the bigger Centre. And this is what I see as … a bubble model in my mind … So, if you start with the 100 people in the immediate Centre, [the] bigger Centre could even be 200 and then the larger network could be 400, so you are doubling at each of those bubbles' RL4.

A very similar analogy was given in relation to the overall effect of the CoE in terms of activity by another participant:

'…by analogy, don't think of a Centre of Excellence as a bubble coming up through a pot on the stove. A CoE needs to create a role in boil where many bubbles are rising simultaneously and coalescing and forming an overall hubbub of activity.' RL6.

These descriptions provide a valuable group of terms of how the CoE emerges through 'boil', and grows in the way described in the 'bubble model.' Through this process, which extends both into the institutionally based research teams with recruitment of PhD students, and finally 'forming' the CoE, narratives describe achieving a **cohesive** whole.

Statements during the 'emergence' of the CoE were also reviewed as HEI focussed, CoE (internally) focussed, or Field of Science focussed and other. However, statements also relate to change or transition points over time. For example, in the initial phase of the CoE, as might be expected, the descriptions tended to be more HEI-focussed:

'… I think the main tensions … were at the setting up stage - because you've got to find a home and you've got to nest yourself within the administrative rules of your home institution' RL17.

Generally, a transition point was noted where statements related to CoE-centric autonomy or internal focus. However, as noted with the CI related statements, different approaches to configuring the CoE could have an institutional layer. For example, some participants deferred to researcher seniority in configuring the CoE, while others worked to mitigate more senior researchers monopolising leadership positions by actively engaging early career researchers (ECRs), even by creating new CoE roles. These multiple approaches not only have a substantial effect on how the CoE establishes but demonstrates the high level of flexibility inherent in the organisational approach.

As the CoE establishes, activities at partner node HEIs may be highly focussed. As all CoE appointments are through their respective home or node HEIs, there are likely to be challenge points. The recruitment of professionals and researchers, including postdoctoral fellows, are conducted by their 'home' institution. In the case of researchers in particular they then will necessarily need to orient to both the CoE and their 'home' institution.

Despite potential structural requirements, these are not necessarily always seen as constraining or conflicting demands.

For example:

'… So, you're thinking … 'how do I engage with the parts of the Centre that are not at [Uni 1]?' I think, and I'm saying 'I don't recognise that differentiation. A Centre is a Centre. It isn't a loose collaboration of entities. So, I don't care whether a researcher is based at [Uni 2] or [Uni 1] or whether the admin staff is here or at [Uni 3].' RL6.

Although most participants stressed there was no real 'steady state', some semblance of the CoE having achieved a point of stability was described as milestones were achieved. For example:

'…I think that now we're in a period of stabilisation and bedding down. All the postdocs have been recruited, PhDs are coming through confirmation and regular meetings. We've had our first national workshops. All those sorts of things that are indicative of things finally settling have been put in place' PL9.

In organisational terms I had been looking to see at what point the CoE might be viewed as an 'operating entity', but descriptions I picked out are much more around recognising a level of coherence and shared identity for those within the CoE. Interviewees used a range of terms to signify the CoE transitioning towards a 'recognisable whole' as: community; collegiality; connection and **coherence**. The concept of coherence aligns well with the description of emergence in complex systems.

At least four mechanisms were outlined which could actively contribute to establishing this 'coherent whole' which potentially enables network formation. Firstly, all CoEs are mandated under their funding agreement to hold at least one annual **'Whole of Centre' event** annually. CoEs aimed for at least initial face-to-face opportunities as important in building cohesion across the Centre:

'…Our AGM and science meeting … where we get everyone together and it actually felt like a big collegial Centre, like a team rather than disparate groups' PL10.

Secondly, the **role of technology** in enabling Centre cohesion was apparent. Now ubiquitous of course, for the CoE2011 cohort investment in video-conferencing facilities was noted as new at the time. By CoE2017, regular online meetings were already the new norm which represented a sociotechnical transition through the more extensive use of Zoom conferencing.

'… so, the whole Centre as a group, have these weekly video-cons that are attended by as many as 50 or 60 people …, as simple as that is, I think it's been

one of the key ingredients to the Centre actually feeling like a somewhat cohesive unit' PL18.

Thirdly, participants described ways **research and professional leads facilitate** the cohesion process. For example, participants describe a pro-active role in engaging others in the 'life of the CoE.' CoEs did this in a multitude of ways. For example, at least two Centre Directors described holding one-to-one meetings with every CoE member to gauge their needs and seek their input to the Programme.

'… my role is connecting people within the Centre to each other and I think that's what the Centre's all about, if we don't do that then the Centre's just a bunch of individuals with individual research grants' RL4.

The final form of establishing cohesion came entirely from **the field of science.** At least three CoEs describe paradigm shifts due to fundamental changes in the field of science or through new interdisciplinary approaches. One benefit describes how such an event both reconfigured the CoE and contributed to CoE cohesion:

'… those two … landmark breakthroughs [in the field of science] … brought the whole Centre together actually to plan out how to restructure' PL18.

These narratives suggest a clear view that the CoEs largely function by retaining this **'cohesive network form'**.

In the next section I look at the other view from the Janus object. How do CoEs seek to engage with the HEI and the ARC as institutional forms?

4.6   The Centre and the institutional environment

"…I'd think probably the single most [important] thing people would say looking inward, [is] that we have organised, coordinated and aligned the university sector into a broader landscape"

Participant's view of the influence of the CoE on institutional ecology

Over the period of the CoE Programme, participants note how CoEs have grown, both in terms of numbers of nodes and CIs, as well as through recruitment of PhDs and associate researchers. As noted earlier, the research programme itself is also continuously pushing boundaries. However, as CoEs become a more recognisable part of the institutional landscape, participants suggest that the CoEs themselves can influence, not only the future CoE Programme, but potentially the institutional environment and that of the wider field of science. From a view of institutional change and systems ecology these form interesting prospects.

One interviewee summarised observations in the change of the CoE Programme over time:

'… Obviously there were the 2011 Centres, but when the 2014 Centres were funded in 2013, the 2011 Centres had not yet had [their] half-term review and I know there were Centres prior to that, but there was not a scheme as such. Much smaller scale than the overall scheme, which meant they learnt a lot' PL15.

Institutionally larger CoEs could raise visibility, but the inherent complexity might also slow down agility to respond to change and/or limit ability for engagement across a high number of nodes. Although some interviewees described concerns for inertia, they did not necessarily see this relating to 'factors of scale.'

'… It could be a tyranny of distance thing, I don't know. Actually, no it's probably not … because [Uni 2] is great, … for whatever reason now our [Uni 3] friends probably cause us the biggest dramas' PL10.

For those directly engaged in establishing a CoE, there is also the underlying challenge noted by a number of CoE leads of 'never having done anything like this before.' To support this complexity, the ARC was noted by a number of participants to act as the supportive institution. The ARC role was noted to be active through convening networks of CoE leads as well as intervening on behalf of the CoE on issues with the HEIs.

In turn, participants of the current CoEs noted how their input to cross-CoE networks and ARC reviews may 'smooth' the organisational path for those establishing the next generation of CoEs.

In this section I look at two observations by the interviewees. Firstly, I outline how experiences within the institutional environment are described. Secondly, I outline CoE responses and how CoEs demonstrate a level of cultural development, with potential to influence institutional practices and, perhaps even, to change the institutional system of research.

4.6.1 "If the VC even knew where we were it would be a miracle"

In allocating statements which related directly to the institutional environment, one narrative that emerged across a number of contributions were examples of 'institutional ambivalence.' These statements referred to perceptions of proximity and distance between the CoE and the Institution which became a theme worthy of exploration.

When participants were asked to talk more broadly about how they saw the CoE interacting with the node institutions, the idea of ambivalence was not suggested. However, the apparent lack of recognition by the institution of the CoE was prominent. This was described varyingly as *"odd"* or *"weird".* Other descriptions included; *"peculiar", "strange", "invisible", "misalignment", "sorry, who are you?"* I also noted on the transcripts that this strange state of affairs was typically met with bemusement.

These comments ranged from those that suggested a fundamental disconnect at the University level:

> '… of course [CoEs are] very prestigious, all universities want them and then once they get them, they don't know what to do with them' PL2.

> '… And the cynic in me occasionally thought that the University wanted to <u>win</u> a Centre more than it wanted to <u>have</u> a Centre. I don't know if that sounds odd' RL20.

(participant's emphasis)

To other examples at the level of the Centre - Faculty level relationship

> '… unfortunately, at the end of eight years I'm still not convinced [the faculties] actually understand what a Centre is' (laughs) PL8.

> '… the - Manager - I think, from the [administering] School … came across and introduced [themself], which was really nice because – you know we'd never met anyone from over there and [they'd] never met any of us. And – yeah we said we'd keep in touch and we haven't' (laughs) PL10.

Or in relation to the senior executive:

'…you could ask me this in three months' time and we could say that 'the … DVCR is really engaged in the Centres of Excellence' – and that could happen, but it's doubtful' PL2.

'… I think they kind of knew we were there but nobody ever took much interest … they probably trusted us to get on with it, but it did puzzle me a little, how little we saw of senior management' RL20.

Some of the participants also intimated that a physical disconnect between the Centre and the Institution may play a role here. In quite separate cases (different CoEs, different institutions, different fields of science) interviewees described a paradoxical effect of this physical or psychological distance:

'…it's quite good space … it's not ideally located … [but] it actually allows us to form a bit of a club here' RL16.

'… we actually went out to a different building that the University rented for us … and that reinforced the culture a lot, but we really had … minimum contact with the University' RL20.

That is, while participants were perplexed by the disinterest of the institution, on balance they saw benefits in being treated with a certain benevolent neglect. For example, the quote in the heading was balanced by:

'… I have to say I think part of the success of our Centre was that the University really had no interest in us' PL5.

The ambiguity of 'place' of the CoE in relation to institutional initiatives was also seen to be challenging in some cases.

'... just to add a further complication, … the Centre where I'm based, sits in an Institute [of Uni 1]. So I'm Director of a Centre in an Institute which includes the Centre but also includes … broader activities that are not part of the [CoE]' RL22.

In contrast, those participants who described a more positive (or at least less puzzling) relationship with the university, also emphasised the importance of visibility of the CoE within the institution. In least one case this aligned with the CoE's physical visibility within the institution:

'… I think … the broader [Uni1] community would be aware … [that the CoE] sits here fairly and squarely in the centre of [Uni1] and is an important part of [Uni1]' PL14.

However, even here there was still some uncertainty of the level of true recognition:

'...I think they are proud of us' PL14.

Another theme, or related topic, that emerged here was the inter-relationships between the

Centre, the ARC and the lead institution's research executive – typically the DVC-R (Deputy Vice-Chancellor Research). Although the examples are fewer - eight (8) participants referred directly to the DVC-R role. These statements indicate the approaches CoEs make to engage with the executive of the HEI. The statements also suggest the level of visibility (or not) of the CoE in the HEI and the recourse to the ARC for advice and resolutions. These could be seen to form part of the CoE's development of 'perception of self.'

Descriptions ranged from those where there appeared to be high engagement with the DVC-R or proximity through line of reporting:

'… My DVC-R is very good at understanding that I'm supposed to try and be a National Centre and lead the National Centre' RL3.

To cases where this was more distant:

'… the DVC-R … I think the first time [they] entered our building was when [they] came for the mid-term review, I think [they'd] never set foot in the building before then' RL20.

And this was in contrast with the view of a more tangible role of the ARC. In particular, the ARC was often noted in relation to transition points in the CoE's life when need for policy input may be high. For example:

'… So … going straight to the ARC and … and saying, 'what's allowed and what's not allowed?' … I don't think the university could have helped with that at all' RL20.

The responses to the semantic questions in the pre-interview survey also provide some insight into the perception of 'distance.' As discussed earlier, the questions were aimed to serve as prompts for further discussion. Overall the five semantic questions can suggest 'measures' of institutional distance in relation to institutional characteristics ie: legitimacy, embeddedness, autonomy, adaptability and orientation. The five questions and responses by the Lead group are shown in Table 4.4 below. As can be noted, there were differences noted in responses when considering the RL vs PL responses and these were explored for other potential correlation of relevance.

The variables which were explored in relation to each of these responses included 'participant variables': Gender; Role and Level of Experience within the CoE Programme or equivalent; and 'CoE variables', including the Science Domain and the Iteration Level, that

is whether the participant had experience of first, second (or third) iteration of a previous CoE.

As gender, role and level of experience were closely correlated - Research Leads were more likely to be men with longer periods of experience in CoEs, these could all be seen as confounding variables. However, RLs appeared far more likely to see the CoE as more dependent on the HEI and were also more likely to see the HEI as a home for the CoE. This suggests they may recognise aspects of legitimacy and/or embeddedness in relation to the HEI. Although they were also strongly oriented to research policy, RLs were potentially more likely to recognise that HEI policy also had a role in shaping the strategy of the CoE. Conversely, PLs were more likely to see the CoE as having a local focus than RLs who identified the CoE as more global.

Table 4.4   Responses to semantic question set in pre-interview survey (n=22).

Pre-interview discussion prompt	Participant Group	More like this	1	2	3	4	5	More like this
How would you describe the Centre's current relationship to the HEI?	Research Lead	Dependent	40%	30%	10%	20%	0%	Independent
	Professional Lead		8%	17%	50%	25%	0%	
How would you describe the HEI's current relationship with the Centre?	Research Lead	Home	10%	20%	30%	10%	30%	Host
	Professional Lead		0%	8%	33%	33%	25%	
Where do you see the Centre's current policy / strategic focus?	Research Lead	Research Policy focus	70%	10%	10%	10%	0%	HEI Policy Focus
	Professional Lead		58%	42%	0%	0%	0%	
How would you describe the Centre's current approach to research development?	Research Lead	Flexible approach	30%	20%	20%	20%	0%	Systematic approach
	Professional Lead		25%	58%	0%	17%	0%	
Where would you place the Centre's current geographical focus?	Research Lead	Global	40%	50%	10%	0%	0%	Local
	Professional Lead		33%	33%	8%	25%	0%	

There was some further skewing when CoEs were considered by Centre type in relation to the field of science. Responses by those in CoEs linked to social and health sciences were potentially more locally focussed and were also more closely aligned to the institutional environment. This could account for the PL differences in responses. However, note that 2 respondents to the pre-interview survey were not interviewed and 2 interviewees did not respond to the survey making a clearer quantitative analysis of findings less precise.

4.6.2   "You wouldn't know half the human race was female."

While the previous section suggests that some aspects of inter-institutional relationship are at best distant, I also wanted to explore the claim that, despite the disinterest of the institution, the CoE participants sense potential to be able to *'realign the university into a broader landscape.'* A further statement which emphasised this case was in relation to the national strategy:

> '…There can be a vacuum in the national strategy - surprise, surprise - but that doesn't cause us much grief because if someone hasn't set the rules, CoEs can kind of set the rules themselves' RL6.

The emerging theme for this section came from looking at the institutional interactions which related to this movement of the CoE within the policy environment. In the early coding process, a subset was created for **'Cultural Environment'** of the institution to capture statements where less tangible aspects of the institutional setting were described as important. Here I was looking to see how participants describe interactions where *'the institution enables the Centre to develop and flourish (or not)'*, For example:

> '… I think the Deans would say they're 100% behind the Centre, you know it's good for the university' PL14. to

> '… So, my job is just to make sure that the madness from the university doesn't get in the way' RL11.

Statements were also identified which suggested a level of (institutional) autonomy as the Centre developed internal policy-making and self-direction and subsets for **'Cultural Autonomy'** and **'Rule and Policy-Making'** were created for these. As before, I used these categories as a guide to allocate statements. Firstly, I was looking at *'how (or where?) does the CoE develop its own ways of acting and policy-making?'*

In terms of Rule and Policy-Making at least three interaction types emerged which relate to structures and decision-making developed to support the CoE's science and research programme. One of these is structures and rule setting for the **sub-agency role** of administering grant funds to eligible recipients within the CoE, for example

> '… We have - a committee of 3 people inside the Centre - [which] scrutinises [grant applications] every year and ranks them and makes those decisions' RL17.

The second form would relate more closely to **self-governance** or a type of Cultural Autonomy to 'set the rules', for example:

'…We had a code of conduct that we would say, 'when you come to our meetings, this is how we expect that you will behave' and that came from the Centre' RL20.

Because participants often emphasised that 'their' policy-making did not extend to override any formal 'rules' of the university, many of the policies were cultural in nature – that is, they aimed to set the working environment and culture of the CoE.

However, one of the consistent areas described as Rule and Policy-Making was more **issue based**. In this case the challenge of **gender equity** in science emerged strongly as the theme. Similarly to the narratives on institutional ambivalence, this was not a prompted question. However, twelve of the 22 participants described diversity and/or gender as an issue and a number of participants highlighted some aspect of diversity and/or gender policy in their narratives.

If we take gender as an institutional construct – which is discussed in more detail in the analysis – as noted in the quote in the title of this section, then the CoEs demonstrate taking on these 'wider' institutions. One participant also lays the gender equity challenge at the feet of the HEI as *'… a leaky pipeline.'* That is, fields such as physics attract a near equal number of women undergraduates but do not convert their participation to academic careers in the field. This leads to a highly skewed gender profile in research leadership.

By addressing this issue as a network across multiple institutions, CoEs may have potential to influence wider university policy, typically as noted below:

'… So, we can set some of our own policies that are above and beyond what the University's expectations are - you know we have our own - Gender, Equity and Diversity Policy' PL7.

The importance of this example is that it demonstrates innovation potential in policy originating from CoEs which may have influence at points for institutional policies and procedures. An example of how this is enacted was described:

'… [we invest in] … various initiatives to try and move the needle on this substantially as well as going to the Universities and asking … 'we'd like our next permanent hire … to join the department to be a woman, please' … so that takes time' RL11.

Even in cases where a Centre was looking at addressing gender and equity more internally, their work was noted to come to the attention of the university:

"… towards the end they got very interested in some of the gender work we were doing and [asked the COO] and I to come and talk to them about that, because that was something the University was interested in' RL20.

In this case the policy development can potentially be seen as a bubble up innovation. In relation to network studies this could be seen as an example of a percolation effect. This potential role of the Centre as a test-bed for institutional policy is an interesting consideration which was further articulated:

> '… [one of the CIs] wanted to do 'quite bold and radical things for gender equity'. They said 'I want to make this Centre a testbed for trying out some of these ideas that might work in universities' RL20.

While it is interesting to note this potential effect of the Centres as a collective, the predominance of CoEs with a strong focus in science underpinned by physics – particularly for the group that contributed to the study - may also raise the expectations that the CoEs have a national role in leading this type of policy focus.

4.7   Conclusion

The findings indicate that both Professional Leads and Research Leads share a close relationship and develop complex interactions in enacting a Centre of Excellence. However, there are also interesting differences in perceptions and areas of focus on both sides. For example, the Professional Leads are possibly more preoccupied with wrangling the researchers, while the Research Leads - although conscious of the need to allocate specific roles to the CIs - are more likely to recognise some of the wider values the researchers bring to the CoE.

In the analysis that follows I move from the institutional lens to consider the network narrative in more detail. I relate the findings of coherence and transitions to walk through the narratives in relation to some of the key network 'classes' outlined by Watts (2004), I also consider whether the changing structure of the Centre as a network-like organisation and its changing periods of information load, can be accounted for by more recent findings in network science.

I then consider some of the unusual encounters and odd experiences in the institutional environment to support the case for the CoE as a distinct organisational form. Finally, I explore the Centre leadership roles in more detail from the network perspective of 'human hubs' who take a substantive role in directing a community of others to sources of information.

Chapter 5   The Centres of Excellence: a network perspective

The dolphins of Doubtful Sound

All scientists share at least one thing in common. They are hungry for data. In 2001 Mark E. J. Newman published the Herculean analysis (particularly in relation to the computing availability of the time) of co-publication networks derived from five large datasets in the fields of medical and physical sciences. Newman based his approach on Milgram's letter experiment conducted in the 1960s (Milgram, 1967) and a later analysis of film actor data. Both demonstrated the 'six degrees of separation phenomenon' in social networks (later popularised in the play by John Gaure and the game, 'six degrees of Kevin Bacon'). While Newman thought some anthropological studies could also provide insights into social networks, he felt they may be too specific to be of universal value. He also reasoned that Milgram's experiment had some methodological holes and that associations in the film actor network may be too transient to extrapolate findings to wider social networks.

Based on these apparent limitations in earlier studies, Newman naturally assumed larger volumes of carefully structured bibliometrics data on science publications would provide greater insights into true networks. He also hypothesised that scientists who had spent considerable time co-developing and co-publishing a paper would produce a more specific view of a 'true' social network. However, Newman eventually acquiesced, writing "... calculating exhaustively the minimum distance, in terms of numbers of links in the network, between all pairs of scientists in our databases for whom a connection exists ... the typical distance between a pair of scientists is about six; there are six degrees of separation in science, just as there are in the larger world of human acquaintance" (Newman, 2001, p.407). This feature held true even in the biomedical community which (at the time) included over one million published researchers.

This led Newman to conclude that even large "... scientific communities seem to constitute a 'small world' phenomenon" - but with some distinguishing variation (Newman, 2001, p.408). Newman found "... the average distance between scientists via a line of intermediate collaborators varies logarithmically with the size of the relevant community" (Newman, 2001, p.408). Newman further hypothesised that variation noted between fields of science may have related to their organisational setting, with astrophysicists being the most gregarious of the physical scientists and medical researchers being on the shy-side of collaboration. Newman suggested that the nature of top-down organization of laboratories under laboratory directors in medical sciences, which tends to produce ''tree-like'' collaboration networks, could be the reason for the relatively low clustering coefficient. This suggested a structural effect of the institution.

Newman noted that for some reason, "... it is less common in biomedicine for two scientists to start a collaboration if they have another collaborator in common" (Newman, 2001, p.408).

Having conquered this task of the large network, Newman then returned to a seemingly more focussed puzzle of the network at the community level. In an interview in 2016, Newman describes how he and Michelle Girvan had noted interesting aspects of community effects when looking at assortative mixing and homophily in social networks - that is, that people seem to associate with those who are similar to them - but noting that there are people who bridge these 'homophilous' groups (Oxford Internet Network, 2016). Their work on betweenness, is defined as "... a measure of the influence of individuals in a network over the flow of information between others" (Girvan and Newman, 2003, after Freeman,1979) and this work is now considered a pivotal study in community network structure and function (Oxford Internet Institute, 2016).

However, the ability to test their community structure network algorithm required further data and the types of data they had to hand were minimal. A case of schism in a karate club and a self-analysis of co-publications between their own smaller known community of network scientists. Fortunately for Girvan and Newman, a group of zoologists had just published a study based on seven years working from a 4.5-m boat on the southern edge of New Zealand, documenting the interactions of a unique group of sixty-four intelligent individuals - the dolphins of Doubtful Sound.

When Girvan and Newman came across the study by Lusseau et al (2003) they would have immediately recognised its value. The dataset was larger and more complex than the "small world" model, but was also a realisable, discrete community network which could be used to test their model. Not only was this a detailed real-world dataset, it had been compiled by observations in real-time and had specifically looked at community structure based on interactions. As part of his PhD studies David Lusseau, with a team from the University of Otago, had documented interactions of the 64 individual dolphins drawing on 600 days worth of observations over a near consecutive 7 year period.

This data proved a close match for Girvan and Newman's model of 'betweenness.' That is, the dolphin interactions demonstrated how closely associated social members linked with other groups to constitute a cohesive community. Lusseau et al (2003) also highlighted the stability of the Doubtful Sound community, noting that "… associations were quite stable and were best described [as] constant companionship" and also, unlike similar studies of dolphins, the group could be

described as "... a small society [which] lives in large mixed-sex schools" (Lusseau et al, 2003, p.402).

Newman and Lusseau were in some respects already beginning to explore what Barabási later suggested, that - "the complex system that we are most likely to tackle first in a truly quantitative fashion may not be the cell or the Internet but rather society itself" (Barabási, 2009, p.415). However, rather than using ever larger databases, they had returned to the more sociometric approach of data from individual interactions. Their next step with the data generated by the Doubtful Sound team, was to analyse how the dolphin community had structured itself and what this might reveal about how the group functioned. This analysis revealed evidence of a type of binary system of communication linked by two key individuals, one male and one female, taking on apparent central co-leader roles in the community. Lusseau and Newman (2004) concluded that the Doubtful Sound dolphins, which were potentially unique because they were a geographically isolated group in a resource restricted environment, had established a society with information brokers in ways that had been similarly recognised in human societies (Girvan and Newman 2002).

This work paved the way for new algorithms which identified inter-related groupings in much larger networks and ways to find 'edge-betweenness', or what Newman later termed 'modularity', to find subgroup communities in a range of networks (Newman, 2006). Newman describes how this and subsequent work on community networks also led to a recognition that community networks are not purely hierarchical or simple dendronic groups (i.e. groups connected to other groups), but are composed of mixed types of networks (Oxford Internet Institute, 2016).

Through his own links with multiple researchers and uptake of their data to develop network models, Newman proves his own case. Newman shows that the steps of separation in science are readily bridged, even when the fields seem widely distinct and the physical distances between scientists are great. Whether the work between Lusseau, now based in Denmark, and Newman was a transient acquaintance, or will go on to result in further studies of phenomena in social networks, remains to be seen.

5.1 Capturing views from the Centres of Excellence

My research aims to understand how CoEs serve as a Janus object to offer insights into both the institutional and network environments. As noted in Chapter 4 participant narratives inform current perspectives of self-organisation of science and suggest a case for emergence as complex systems forms. The preliminary interpretation of findings in Chapter 4 considers the understanding from institutional theory. This chapter provides an analysis which draws on network science to consider the network-like aspects of the empirics from the CoE study.

In following the literature of institutional theory and network science we see how scholars from both fields have considered questions of structure and organisational function or behaviour. In drawing the findings together from across the three studies, I look at both complexity and paradoxical perspectives as proposed by Meyer and Höllerer (2014). In particular I consider how findings from the CoE study, taken through the lens of institutional theory, can be augmented by a closer consideration through models developed by scholars in network science. This analysis provides an overview of how CoEs establish a range of network-like forms. A further layer then is the consideration of the experience narratives of participants in understanding how the institutional environment might influence the formation and function of the CoE as an organising form.

Narratives of proximity, or distance, effects in the institutional environment are of particular interest. Some cases also give an insight into the (perhaps expected) discomfort of CoEs in making a place in the institutional environment - '...we're triply embedded.' While others describe expectations of being of more tangible interest or recognised value to the institution '...[at one point we had] ...five laureate fellows in our Centre and I'm like, if the VC even knew where we were it would be a miracle, right.'

To develop the analysis, I 'test' the interview narratives in relation to the set of network models proposed by Watts (2004). These include models by Dodds, Watts and Sabel (2003) which extends earlier organisational archetypes to 'test' potential for single scale organisational models to be considered as multiscale networks. They define these as "… [networks which] display connectivity at all scales simultaneously" (Watts, 2004, p. 12518). Of value too is that these models are tested for structural 'robustness' via the outcome of the sequential removal of nodes at different sites in the network. They can also be tested for 'congestion', or its converse, the level of information exchange, through a study of network behaviour.

In adapting these models to the narratives, I rely on descriptions for the models noted by Watts (2004). The narratives are considered in relation to work by Ramos and Ford who suggest a process for network pictures. These first look at how actors might represent scale and structure, then processes and their own personal positioning to build up a perspective or 'picture' of the network (Ramos and Ford, 2011, p.449).

As I had asked participants to 'zoom out' from the CoE, this also allows a consideration of more specific contexts or perceptions of complex environments as a type of "...'second-order' complexity [as a] narrative perspective of reality" (Ramos, Henneberg and Naude, 2012, p. 954).

This approach also borrows strongly from Weick's work on sensemaking as a form of contextual rationality and the concepts of social construction (Weick, 1993). In addition the approach has resonance in relation to scale and structure based on Weick's proposition for loose coupling in educational institutions (Weick, 1973).

This analysis considers four areas to create a series of network narratives. I do this firstly by considering the form and function of CoEs in relation to network models described by Watts (2004). Through this analysis I propose that CoEs present a range of network-like forms. I also consider the Co-Lead narratives in relation to findings by Girvan and Newman (2003) and then consider some of the stranger institutional encounters and challenges in relation to work by Kleinberg (2000). The analysis also reveals how paradoxical narratives suggest evidence of emergence of relevance to understanding complex systems. In synthesising these network narratives with the analysis of institutional theory, I consider ways this study conforms with a proposition by Meyer and Höllerer for approaches which account for "...complex landscapes of pluriform organisations." (Meyer and Höllerer, 2014, p. 1224).

5.2 Network narratives - emergence of the Centres of Excellence

Two distinct network narratives emerged from descriptions of growth and activity of the CoE. The first relates to growth; 'bubble'; and the second to information exchange; 'boil.' These narratives differ from more institutional projections of Research Centre interactions as adjuncts to national research systems. For example, in Bell's study of similar national Centres of Excellence programmes, an assumption of CoE to industry innovation was that interactions [should] follow linear paths to produce particular outcomes of economic value. Bell notes the expectation that "… industry and university scientists will interact, that technology transfer will take place, and that … industry will become more competitive" Bell (1993, p.4).

While this national imperative is recognised, RLs can act in a way that counters institutional expectations:

> '… there's government pressure to work at higher levels of aggregation, so national levels, state levels and so on, whereas the real action is down there at the communities' RL17.

A similar counter view to the linear industrial model is that CoEs can create a non-institutional environment. For example, narratives which emphasise the cultural role of the CoE as distinct from that of the institutional experience:

> '…it's just a wonderful … hothouse for young researchers to be in, a much more exciting and …supportive environment than they normally would' RL17.

The 'boil' metaphor, also suggests that the CoE enabled activities and interactions are a direct source of this 'hothouse' environment. In a network sense, these activities can be seen as modes which support information flows across institutional thresholds. However, narratives also note potential for lag periods when the CoE Leads have to switch energy and focus to contend with the institutional field. Both the paradoxical behaviours and the position of the 'CoE as a Janus' are also relevant to forming an understanding of the 'institutional life' of the CoE.

5.2.1   A starter dough of scientists and the bubble of growth

'… Yeah, it really grew outwards from probably half a dozen people who tossed ideas around and wanted to get … a combination of things that would continue big questions that we were interested in, but link those together to scale to a centre that could do much bigger things' RL17.

The concepts of emergence and growth are viewed with complex systems as organic processes. From the inception of the CoE, a culture of scientists is started which then 'bubbles out' as newcomers are added. Origin stories which relate how a group of researchers comes together to 'design a CoE' with interdisciplinarity was described in one case as a 'creative skewing.'

'… we began to join some of the dots, but not all of them and it wasn't our intention to have a fully baked cake, you know, we wanted to have something with the ingredients that would work if they were put in the oven for seven years. So that's how it grew. I think it was partly something of a colleague by colleague phenomenon' RL17.

Initiators who conceive of and co-design an interdisciplinary proposal can form a disparate collective. One description perfectly reflects the formation of a small world network – not too interconnected, not too random (Watts and Strogatz, 1998). This understanding goes back to earlier evidence noted by Crane who described the underlying expansive nature of the 'invisible college' and re-emphasised by Bell in the Canadian study "… a social circle characterised by direct and indirect ties among many but not necessarily all of its members" (as cited by Bell, 1996, p.332).

'…I knew him a bit but others didn't and [J], who's an IT person, I knew her and ... others didn't, and then there were other people who were known by others but not by myself' RL17.

This demonstrates the move from a random group of scientists toward a more ordered small world. If all goes well these same people will then transition to form roles as a group of CIs who constitute and establish the CoE's collective governance. In most cases a level of diversity is retained in this process:

'… [we] only [had] 8 CIs - so it was quite contained ... one area where it was courageous, … was that we involved many disciplines.' RL.

In some cases, the field of science might also naturally skew the way this group forms,

'... we certainly don't adopt the sort of more military style model that I detect, especially in the medical sciences … [our field of scientists] are sort of anarchists and we like to do stuff in our own way' RL17.

Alternatively, some CoEs may be shepherded by the institution and this may be a more ordered grouping from the inception of the Centre,

'… originally, we had 19 CIs which were [also] the core CIs from the beginning, from the proposal stage' PL1.

This description also resonates with Newman's findings of different levels of clustering in fields of science (Newman, 2001).

In relation to the narratives there is evidence that CoEs, despite potentially starting at similar points in cohort groups, can readily self-design. In this process, the narratives suggest they adopt different network-like structures. In building up the network narratives it is clear that, while multilayered, there are potentially different network structures at play throughout the evolution of the CoE. Transition periods may also be particularly important in supporting network formation.

An example of a network narrative based on the overview of the formation of the CoE through to the description of a 'cohesive whole' and then into the more 'Gestalt' or scale free form is shown in Figure 5.1 below. The narrative is based on a node leader (indicated in light green.) I have also suggested the direct engagement by the RL (dark green) who also participates as a Chief Investigator throughout the CoE and the PL (purple) who plays a role in interconnecting – at times informally - throughout the layers of the CoE. The lighter purple and broken line symbolises this more indirect, network-making role in comparison to the direct (dark purple) role of the PL.

The network models are based on Watts' (2004) and the mapping of the classes of networks described in this work are as shown in Figure 2.6. As noted, Watts provides a descriptive view of the models which allows accessibility to orient these findings toward organisational studies. In this way they can inform network perspectives of the complex emergence of network-like organisations.

Figure 5.1 Compilation of a Network Narrative for researcher groupings in a CoE in relation to network models noted by Watts (2004)

NETWORK NARRATIVE FOR A NODE LEADER AT A PARTNER NODE WITH TWO CHIEF INVESTIGATORS IN A REPEAT FUNDED CoE

INSTITUTIONAL NAVIGATION
So I'm the first port of call for administrative matters - the person that has to be the administrative connect [and] contact point as well.

SMALL WORLD (BONDING) – CI GROUP
… our Centre's always had a … strong core, of a small number of people who are at the core of it, the originators and the … core leaders, thought leaders … we've seen things evolve from one Centre to the next

CLIQUE / CLUSTER (BONDING) – RESEARCH GP
… so, within each academic group you've got a subgroup …which is the [CoE] funded people - we're like a lot of little one man and one woman bands…so it's Researcher A's Group and the Researcher B's group [etc], these are the fundamental business units

FAMILY (BONDING)/ COMMUNITY COHESION (BRIDGING) WIDER CENTRE
… but then as they go back to their other labs and their offices with their other group members 'their family', they go back and interact with those people, so the [CoE people] are then intrinsically connected and networking back to all those groups.

GESTALT - TRUE NETWORK PHENOMENON
…so, if you start with the 100 people in the immediate centre and bigger Centre could even be 200 and then the larger network could be 400 so you are doubling at each of those bubbles.

LEAD HEI (NODE)

PARTNER HEI (NODE)

PARTNER HEI (NODE)

SMALL WORLD NETWORK

SINGLE SCALE COMMUNITY NETWORK
(Multiple Research 'Nets')

REAL-WORD SOCIAL COMMUNITY

REAL-WORD SOCIAL COMMUNITY

GESTALT

NETWORK MODELS CONSIDERED

Kleinberg (2000) Generalised small world model. Model linked to lattice substrate – (NB. this overview assumes institutional links are 'substrate' links and builds on Newman's idea of nodes embedded in space)

Watts and Strogatz (1998) Small World Network. Also Granovetter (1973), based on Milgram (1969)

Dodds, Watts and Sabel (2003). Multilayer Network – Core Periphery model

Girvan and Newman (2003) Single scale community network model – multiple small worlds with agglomeration algorithm to test connectivity

Girvan and Newman (2003) Shortest path algorithm model tested on real-world social community. Data from 7 years of social observations of dolphins in Doubtful Sound New Zealand by Lusseau et al (2003)

Scale-free networks (Albert and Barabási, 2001)

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As indicated in Figure 5.1, the narrative fits with Newman's proposition that social networks may be made up of mixed 'types' of networks from a modelling perspective (Girvan and Newman, 2003). Based on the model descriptors in work by Dodds et al (2003), the CoE may transition to a core-periphery model. This has a highly connected core at the top (the CI group) with less defined connections in the lower rank groups. This closely matches the narrative of stages of the CoE development as the CI group becomes more structured as an executive, while recruitment of postdocs and a professional group start to form new groupings.

However, as noted by Dodds et al (2003) there is potential for a multiscale network, which is denser at the top but combines local team and random networks. As we move out from the CI group, the CoE also establishes these 'new nodes' – researcher and professional participants in each HEI – and more random connections across the CoE. These can be conceived as being added in real-time, similarly to the stochastic approach taken by Dodds et al (2003) in developing their multilevel models.

A multilayer core periphery class, as modelled, also demonstrates some characteristics which appear similar to CoEs, which are: high growth potential (second to that of a multiscale network) and a high level of potential connectivity (greater than a multiscale network). Of interest in the modelling by Dodds et al is that the multiscale network has a low congestion centrality – or higher potential for information exchange. In contrast the core-periphery model has fluctuating periods of congestion as nodes are added (Dodd, et al, 2003, p.12519). This mixed multiscale network aligns with the narrative of the next layer 'labs' and research groups. Aspects also align with studies of community structure networks (Girvan and Newman, 2003), even to the extent that the next layer is described in terms of smaller 'family' groupings, which extend out to the wider institutional groups.

CoEs could be viewed as a constituted research subunit in relation to the larger institutional environment (the Organisational Research Units or ORUs as noted in early studies in the US for example by Gieger, 1990), and therefore somehow embedded in this institutionalised landscape. However, this was not the view conveyed by most participants -

'... a Centre is a Centre. It isn't a loose collaboration of entities' RL6.

A number of participants also described the outcome of the Centre as beyond the bounds of the institution by using the Gestalt narrative,

'… [the Centre] did very well, we really did demonstrate that the whole was greater than the sum of the parts and there was a lot of really good collaboration based around complementary expertise' PL8.

From the literature this suggests an open area for exploration, which aligns with the proposition that science "… cannot be captured by descriptions of its organisational form" (Lepsius, 2017, p.51). This finding also aligns with self-organisation in complex systems. As noted by Weber and Varela (2002, p.114), "... this notion of a 'whole being larger than the sum of the parts' has been familiar for a long time. But the rise of studies on self-organisation tells us just *how* the whole is more."

This concept of the Gestalt was not limited to those Centres which were unconstrained by matters of commercialisation, but also by those which had a more industry focus. These narratives are in keeping with findings which demonstrate the scale-free nature of collaboration networks in certain fields of science (Albert and Barabási, 2001) and the global nature of science development (Leydesdorff and Wagner, 2008). However, this description in sociometric terms is also clearly equivalent to the later demonstration of the small world network (Watts and Strogatz, 1998) and the community network structure of Girvan and Newman (2003), in identifying potential interactions and ties which result in a sense of a larger 'whole' across the community of science.

The CoE origin narratives can appear highly biological but can also be told from a more institutionalist perspective, that is, one that explains social structures typically in terms of their status, place and power. Networks too can be described in these terms. For example, once the CI layer of the CoE has formed we could say that a distinct order 'or clique' is established by the CIs which, over time, 'bond' with all the CIs. These tightly bonded interactions are said to lend social capital (SC) to the network formation (Hexmoor, 2015, p.88). This social capital is added to by 'bridging', for example, as CIs reach out into other communities of science both within and beyond their home institution. This 'egocentric' position - at least from the perspective of the individual node (the CI) - is the basis for Bonacich's centrality (Bonacich, 1972). As noted from the integrative review, this understanding of social networks as 'egocentric' is typically applied to cases considering both institutional theory and networks in their studies.

In cases where narratives describe a successful further iteration and funding of a CoE, the narrative takes on a more institutional character. Although the second iteration often draws on the same 'DNA' of the first CoE, some participants describe a 'lessons learned' response to set out new rules and; '… So yes, of course we learned, there were a

number of things we did to try to capture strategies that would strengthen the operation of the Centre, of the new one over the old one.'

These second iteration CoEs have a starting point beyond the small world of the novel CoE, which might suggest a second iteration CoE can't go back to a more radical state '… we had to learn how to build structures [for our first Centre] which led to our research having impact and I think we're very effective at that now.'

Although next iteration CoEs are (according to the ARC rules) expected to be a wholly 'new' in terms of the science, structurally the CoE can be re-established with the same leadership and at least a similar subset of CIs. In this case established 'social capital' is retained, and this can clearly be described in institutional terms: '… one evolves through that first Centre. We gained a stronger reputation and more credibility with our partners.'

However, in at least one CoE there was a more radical approach of re-imagining the process to initiate a more open, social approach to start a new small world and begin again from scratch. This demonstrates the radical potentiality of the CoE Programme.

'… [one of the Centre Leads said] the first Centre was born in smoke filled rooms, it was people who were already leaders of the community getting together … I want to bring young people in, I want to bring people in with fresh ideas, let's have an open call in the community' RL20.

In this case the narrative was highly related to the field of science which could be considered the site of 'social network capital.' This field also had a high level of understanding of the science field in terms of a global shared resource. In this way the CoE, underpinned by its particular culture of science, potentially demonstrated an ability to function highly in terms of Ostrom's view of collective governance (Ostrom, 2000) which was outside the CoE itself.

As evidence from the combined CoE narratives there are clear lag phases, bursts of growth, followed by a sense of cohesion and then either a decline or a further iteration for a small group of CoEs. Across the Programme this lends a view of a highly socio-biological system. For many CoEs there is also a hiatus period through the mid-term where Centre Leads re-orient their focus to submitting a further bid for funding. This is an interesting period which some Centre Leads describe as '... taking them away from the Centre.'

These narratives also align with the concept of fields in neo-institutional theory effects, ie, "… fields that have stable and broadly acknowledged centers, peripheries, and status orders will be more homogeneous, both because the diffusion structure for new

models and norms is more routine and because the level of interaction among organizations in the field is higher" (DiMaggio and Powell, 1983, p. 156). However, as suggested by the models by Dodds et al (2003), there is potential for different densities and non-uniform 'diffusion structures' or information exchange potentials in multiscale networks. This may be what allows CoEs to retain a level of internal heterogeneity, as well as appear, through the narratives, to form different network-like forms.

The other side of growth is the story of decline, often with a narrative of dissipation and loss, as the CoE fulfills its original remit and completes its lifespan. Models which remove nodes also give a sense of 'robustness' and an indication of how CoEs might close. Dodds et al consider this both in terms of "… connective robustness (the capacity to retain connectivity even when individual failures occur) and congestion robustness (the capacity to protect nodes from congestion)" Dodds et al (2003, p. 12519). There were two narratives of interest here – the first of 'dissipation', which in network terms suggests the underlying robustness of the CoE was weak. Interestingly the core-periphery model suggests relatively low connective robustness. The second narrative was around 'legacy.' In this case the CoE narrative suggested the CoE retained cohesiveness and even established a cultural memory.

I look at the potential relevance of robustness in the CoE case in more detail below. Firstly, by looking at the structural, organising level of the CoE. Secondly, I look at how the CoE responds to or addresses cohesion in the case of diversity. This relates closely to network phenomena in relation to the Matthew and Mathilde effects – that is, the phenomenon of preferential attachment (the Matthew Effect) versus the potential drop in network robustness as nodes are removed as an extrapolation of the Mathilde effect.

5.3 Synthesis of narratives – a pluripotential view

In synthesising the findings, I draw together five 'narrative typologies' to provide an overview from the CoE study. The typologies, as illustrated in Figure 5.2, below are not intended to suggest a set of 'archetypes of CoEs', nor do they suggest a 'preferred type.' As shown in Figure 5.1, CoEs also move through phases of self-organisation through their lifespan which may result in different network-like forms of organising – so this view of the narratives should not be viewed as static states. In non-teleological terms, these typologies illustrate a synthesis of 'how' the CoEs and their interactions 'are', in order to make sense of a level of self-organisation and emergence in complex environments (Jain, 2017).

Each 'typology' represents five closely shared 'network narratives' from at least two CoEs engaged in different fields of science - at least one CoE engaged in the physical sciences and one engaged in the social, health sciences or the humanities. The exception is the 'field of science' network which most closely applies to the narrative of one CoE. Of interest is that CoEs which represent iterations of the same field of science could be classed into three different CoE typologies - indicating dynamics of self-organisation within the field of science itself. Although at least one CoE was also engaged in environmental sciences and three in human health sciences, no CoEs with a predominant focus on biological sciences participated in the study. No doubt these CoEs could have further perspectives to offer.

Figure 5.2 relates the five network narratives in relation to potential orientations in the institutional theory literature. These nominally position the narratives in relation to their institutional perspective. This is based on the types of institutional experiences and interactions described in these narratives. Each typology suggests eight attributes based on closely shared narratives which could contribute to the pluripotential outcomes of the CoEs. These attributes can be grouped as:

1) Enacting the CoE

- how Research-Professional Co-Leads work;
- how self-organisation is enacted;
- how focus is given to enacting the CoE as a whole.

2) Experiences and responses to the institution through emergence

●how the CoE experiences the institutional environment;

●how the CoE responds to/views recognition/legitimacy.

3) Network perspectives

●how engagement beyond the CoE is enacted/focussed;

●how the relative robustness of the CoE as a network-like organisation is
described;

●how CoE incursions or activity lead to institutional change and/or changes in the
field of science (other than science contribution).

I discuss each of these groupings in more detail below.

Figure 5.2 Synthesis of network and institutional narratives as 'typologies' of the Centres of Excellence

EMBEDDED NETWORK (TENDENCY TO RULE & ROLE MAKING)
- Research and Professional Lead share high level of experience in the institutional environment
- Active in shaping CoE roles and policy via the ARC
- Focus on supporting intra-CoE effectiveness
- Cognisant of 'managing' the institutional environment
- May gain legitimacy through focus on projects of strategic national interest
- Actively build institutional engagement via CoE Programme
- May be robust through tendency to institutionalise
- Effective in influencing the CoE 'place' in the institutional environment.

TRANSDISCIPLINARY NETWORK (TENDENCY TO RANDOM NETWORK)
- Research and Professional Lead share entrepreneurial focus
- Actively work to build 'CoE identity' to engage in complex organisational environment
- Focus on sector/industry and/or government engagement
- Can experience navigation and inter-CoE connectivity challenges via institutional environment
- Effective in gaining legitimacy through partnership formation
- Active in engagement as national service / discourse to promote novel field
- Can be least robust if self-organisation is weakly enacted
- Effective in testing governance arrangements - but can get 'stuck' in particular governance / strategic modes

FIELD of SCIENCE NETWORK (MOST LIKE SCALE FREE NETWORK)
- Research & Professional Lead share similar field of science background
- Actively work to build science leadership capacity through early career researchers
- Focus on 'whole of network' engagement
- Can experience administrative distance in institutional environment
- Effective in gaining institutional recognition through science discovery
- Active in scaling up field of science
- Robust through potential to scale
- Effective in undertaking organisational and governance experiments

KEY:
Approaches to enactment
Institutional Environment Experiences / Responses
Network perspectives

Institutionalist approach

Structuration rational collective view

Contextual rationality symbolic interactionist view

CoE

Field of science ontological commitment view

Open system view

NURTURED NETWORK (COMMUNITY STRUCTURE NETWORK)
- High level of synergy between Research and Professional Leads
- Focus on intra-CoE trust and culture from an effective small world foundation
- Actively work to build community cohesion and bring early career researchers into leadership
- Can experience space and ambivalence effects in the institutional environment
- Effective in creating institutional recognition through CoE generated policies
- Active in growing wider community of science as an experiential and nurtured environment
- Robust through community structure through life of CoE and passing on cultural legacy in field of science
- Effective in achieving percolation of cultural policy into the institutional environment and field of science

OPEN NETWORK (CORE-PERIPHERY NETWORK)
- High level of trust between Research and Professional Leads - may be clear role demarcation
- Actively seeks input from other fields of science, but may retain senior / early career researcher split
- Focus on high intra-CoE information exchange
- Can respond to institutional constraints by work-arounds
- Effective in retaining autonomy & flexibility through focus on open science approach
- Actively work to build a conduit for partnerships via 'CI group as a small world'
- Robust through high level of connectivity - but succession in some fields may be an issue
- Effective in influencing practice change in the institutional environment

5.4 Enacting the Centre

5.4.1 The Human Hubs: The CoE Leads

5.4.1.1   A node by any other name

The use of the term 'node' in the ARC CoE Programme is symbolically important in an institutional sense as well as semantically problematic. Just as the titles 'Centre Director' and 'Chief Operations Officer' don't necessarily sit well with the reality of the CoE roles, the term, 'institutional node', is a misnomer. From the narratives, the HEI itself does not hold any pivotal or ongoing role in CoE interactions.

Applying role titles, such as 'Centre Director' suggests a case for 'coercive isomorphism' as proposed by DiMaggio and Powell (1983), that is, that informal groups need to "… lodge responsibility and managerial authority, at least ceremonially, in a formally defined role in order to interact with hierarchical organizations" (DiMaggio and Powell, 1983, after Kanter, p.151). Centre Directors emphasise the informality of their role, in almost uniformly declaring they don't actually direct anyone. Similarly, the COOs recognise their role is quite different to the role of their institutional equivalent. Nevertheless, these titles may allow the scientist - professional team to attain a level of recognition as legitimate players in the institutional environment.

However, there is limited indication of any ongoing 'coercion' of the CoE by the HEI. An exception may be noted in the efforts by the CoE leads to seek recourse and recognition via the Deputy Vice Chancellor-Research role. Another example would be the conversion of the title 'Node Leaders' to 'Node Directors' in a second iteration CoE as a similar signal to gain formal recognition or to find role equivalence in the dominant institutional environment. Within the concept of collective governance, these efforts to reference the institutional environment are seen to create "... a constant obstacle to the maintenance of egalitarian or collectivist organizational forms" (DiMaggio and Powell, 1983, after Kanter, p.151).

However, from a number of narratives, following the difficult period of negotiating the partnership configuration, many CoEs readily revert to a predominantly collectivist governance and operation and the titles remain as a remnant of this early establishment phase.

The institutional (even contractual) use of the term 'node' in the CoE Programme could also be read as an institutional co-optation of the network. On one hand, the ARC

may seek to emphasise this network term as a signal to the institutional partners that their role is not simply to administer and co-invest in the programme, but to also act in the spirit of the network-like nature of the Programme. On the other hand, the HEI may adopt network terms as part of an institutional tendency to simply aggregate symbols (after Marginson, 2017).

Although this research does not extend to consider any co-effects of institutionalisation on the ARC programme, as noted earlier, participants describe expectations that subsequent cohorts of CoEs tend to both more ambitious and start 'larger' with more partner HEIs and more CIs. This overall growth of complexity was also described by professional participants via the establishment of CoE contributors to the ARC committees (in additional to more established research and review structures.) The establishment of formal structures, further rules or guidelines could be seen as an effort to further institutionalise the CoE Programme (Tolbert and Zucker, 1996, p.182).

This poses a challenge for CoE Leads to effectively work together to 'shepherd' the network. How different CoEs achieve a balance between engaging in the institutional environment and develop their own network-like form is explored in more detail below. In particular, this approach relates to the narrative of concern in more recent CoEs of '...what to do with all the CIs?'

5.4.1.2 Shepherding the network

By seeking the contributions of both Research and Professional Leads who are engaged to 'bring life to' and then sustain a CoE, the narratives allow a clear consideration of these roles as 'human hubs' and the network-like dimensions of their roles. In some cases, I was able to interview participants as a duo within the same CoE and gain an appreciation of how they worked together. Research Leads described themselves in terms that demonstrated their adherence as a fellow Chief Investigator among their peers, describing the nature of their role as: '… a violinist within an ensemble'; '…a ringmaster'; '… I'm a steward, I don't try and do', while also noting where this peer relationship is reinforced as an institutional fact;

> '… I have no authority over my CIs. I can't hire and fire them. I can't make them do anything' RL6.

as well as where this balance extends to shepherding institutional relationships:

'… I have sightlines to each node and responsibilities to ensure that each University is getting their own bang for their buck. That each University feels the love' RL3.

For the Professional Leads too, narratives involved shepherding their own CoE, but also demonstrated a view to the way the Programme as a whole circumnavigates the institutional environment;

'... it was interesting when [Uni1] got their CoE, ... - the Dean of the Faculty, who I knew, had rung me up and actually said I'm just getting advice on where we should position [the CoE] in the [institutional] structure' PL5.

This comment also signifies the Professional Lead network as a growing source of authority on organisational design for the CoE Programme more broadly.

For the Research Lead viewing the Centre as a whole, the network-making role is also described as making external connections in ways that also circumvents more institutionalised science structures;

'... If you're in Germany and you want to collaborate with the [national science body] it's almost impossible, if you want to collaborate with the [national science body] via us, it's trivial. So, we act as a conduit if you like for much, for a lot of the stuff that happens' RL6.

Similarly, Research Leads describe how the CoE structures itself to achieve a network-like design, albeit within the structural constraints of the institutional environment;

'...the way we overcome that is multiple interwoven nets in terms of a network to try to break silos, and it's really hard because [the Chief Investigators are] all employed at their own institution, they all report through their Heads of School and their Deans' RL6.

As shown on the left of the narrative in Figure 5.1 we can also follow how the (aptly named) node leader actively works to connect through the multiple layers of the Centre, noting how the narrative follows the actors from 'I' to 'We' to 'Them', and then to a point where the description of the CoE becomes diffuse. Here we can see the active point that the node leader takes in supporting information seeking and network making within the CoE's diverse groupings,

'... my role within the Centre is in connecting people to each other and I think that's what the Centre's all about, if we don't do that then the Centre's just a bunch of individuals with individual research grants' RL4.

In network terms, Kleinberg applies the term **'authority'** for a highly referred to node (or hub) in information terms - for example, in directed searches in the web which point to a particular page (node or vertex). An example of Kleinberg's model is its application to rank publications in citation networks. As noted by Newman (2004, p.44), "...Kleinberg refers to a vertex that is pointed to by highly ranked vertices as 'an authority' as likely to contain relevant information … A vertex that points to highly ranked vertices is referred to as a hub." This view of the model in relation to the CoE Leads suggests 'human hubs', who direct information seeking others as a valuable characteristic in sociometric terms. This attribute could also form a prominent contribution to establishing and sustaining the network-like nature of the Centre.

5.4.2 Oscillations and congestion: CoE emergence as a self-organising form

Although the CoE in its initiating phase can be seen as a 'small world' of Chief Investigators, it is concurrently subject to strong institutional (downward) information pressure. In numerous studies reviewed in the integrative review, the expectation is that 'diffusion', 'adoption' and 'technology - or policy - transfer' occurs through this top-down relationship with the dominant institution, while 'innovation' might be more likely to originate outside or at the periphery of such institutions. There may be an expectation or effect that the CoE in a dominant institutional environment may seek to 'mimic' a more institutional governance structure - for example, by formulating a small executive which represents the institutional partners.

Narratives where participation in leadership was constrained, either through self-imposed or by institutional design, was noted to potentially 'lock' the CoE into a certain configuration. For example -

'...because although I think the executive ended up forming quite a good relationship … we spent a lot of time on that, when a lot of the other CIs probably felt quite left out and we never … found a good way to engage with all the CIs' PL10.

However, the narratives also note very different approaches, such that forming governance becomes more CoE-centric. These narratives included potential to change configuration with growth - for example a decision by some CoEs to actively support early-

career researcher progression in leadership roles. Another approach configured the governance through science themes which aimed to retain flexibility to revise science-driven objectives.

From a network perspective a newly annointed Centre Director first needs to form and engage the small world of CIs to transition from a science group to address more institution-like demands. Here some RLs note how they initially had to

'... embed the Centre in the administrative rules of your home institution' RL17.

and take on board the 'rules of the game' from the funding institution and the multi-partner agreement.

As Leaders then move to a growth phase we can assume that this will be asynchronous and at times unwieldy as each new appointment to the CoE is made under individual partner organisation 'rules.' This type of growth is likely to approach the core-periphery model by Dodds et al (2003), which, when expanded as a multilayer network, is punctuated by distinct lag phases and the network experiencing unusual oscillations in information flows. As Dodds et al note; "… In particular, the congestion experienced by the most congested node in a core-periphery network can increase significantly as more edges are added, before falling again, giving rise to oscillations [in the level of congestion of the network]" (Dodds et al, 2003, p. 12520).

Some participants describe the experience of a disorientation in the early growth phase of the CoE. It is reasonable to suppose that as new 'nodes' (HEI partners or Research Fellows) are formally added to each group in the CoE's periphery there is potential for 'high points of congestion.' This can be followed by periods of effective information flow. If we take the Research Lead in the early stage of the CoE to be a key node we can also appreciate this oscillation effect having an impact at a personal level - 'the ARC Bus'.

This finding fits with descriptions of the challenging emergence and period of establishment of some CoEs who 'work hard' through this emergent phase. As the highly connected 'top layer' of the network – the CIs generally establish a governance group in parallel with the introduction of a professional layer - we could account for these potential 'lag phases' as part of the pragmatic set up of any new organisational form. This was described clearly as:

'... the 9 months of hell which fell between the euphoria of knowing we got the proposal and the sober day of starting the Centre' RL17.

Some of the 'rule-making' processes described in second-iteration CoEs may relate to efforts to retain a level of control over the inevitable unmanageable levels of institutional demands. As part of the second iteration process CoEs could adopt more institutional approaches, and examples of mimicking, or being cognisant, of others in this process was noted. This included setting formal Full Time Equivalent (FTE) levels for CI commitment and changing role titles as noted above. This signifies efforts to institutionalise to retain 'order' in what is possibly becoming a more complex environment or wishing to avoid the potential 'disorder' of the early phase of a core-periphery type network.

Conversely, for one Research Lead there was an acceptance that minimising the impact of information overload on the CoE was part of their role. In network terms this perfectly describes the type of congestive robustness offered by a protective, effective human hub –

'... so my job is just to be an umbrella ... to make sure that the madness from the university doesn't get in the way' RL11.

For CoEs moving toward a second iteration, in particular where broader networks may also be inherited from its predecessor CoE, this trade off with network growth may not be such an issue. If the CoE has arrived at a more formalised structure or known set of relationships, there may also be less disorientation in the formation of a second iteration CoE. As noted by Dodds et al (2003), a more hierarchical structure may limit the discomfort of oscillations in information exchange over time, but its overall robustness and growth may be weaker than the multiscale model. However, there was at least one CoE prepared to throw out a successful first iteration and start wholly anew.

5.5 Experiences of the Institutional Environment

As noted in Chapter 3, Research Centres linked to Higher Education institutions have been studied for their equivalence to institutional faculties and departments in the US (Ikenberry and Friedman, 1972) and in Australia (Harris, 1989). They have also been reviewed as new structural arrangements for engagement with industry in Canada (Bell, 1996) and Australia (Dodgson and Staggs, 2012). CoEs and similar arrangements have also been reviewed as potential models in emerging economies to lift international research collaboration (Beerkans, 2009), to build research engagement with stakeholders (Wagner, 2018) and to increase national research capacity in specific fields (Zgaga, 2014).

Studies which align closely with this research have also sought to 'get inside the Centre' to look at practices and perceptions of scientists, in particular those conducted in the Centres of Excellence programmes in Norway and Sweden (Borlaug and Gulbrandsen, 2018) and the National Science Foundation Science and Technology Centres in the US (Boardman and Bozeman, 2007).

This section considers some of the 'unexpected' findings in my empirical study: the strange narratives of the institutional environment. These differ from more expected descriptions of how researchers might consider the 'granted' environment or how Research Centres might be 'expected' to act in relation to institutional expectations. There are similarities with Boardman and Bozeman (2007) who anticipated a level of institutional ambivalence or resistance by the faculty to researchers working in National Science Foundation projects. They were surprised to find institutional ambivalence was more likely than any negative response. Similarly, Borlaug and Gulbrandsen (2018) noted a difference between CoE researchers and their attitude to institutional logics of innovation and excellence when compared to colleagues more clearly expected to achieve industry collaborations.

5.5.1 'Bumping up' against the substrate - foraging in the institutional field

The experience of the institutional environment and the eventual emergence of the CoE is clearly told here:

> '...And so in the early days I tried exceptionally hard to build good relationships with the faculty ... and tried to have weekly meetings with ... anyone who could have any influence over what we did, but that was very time consuming ... and then, as things smoothed out, the need to have those - interactions started to reduce' PL19.

Kleinberg's reworking of Watts and Strogatz's Small World as a network navigation model considers information seeking or 'foraging' beyond the immediate neighbourhood. Also basing his work on Milgram's letter experiment, Kleinberg describes the process and the time (not just the steps) that some 'nodes' take to source information beyond their immediate neighbourhood of contacts (Kleinberg, 2000). This generalised small world model could help tell the story about the ease with which the early CoE, as a small world within an institutional environment, interacts in the Kleinberg's projected 'substrate'.

Watts struggled with a such model that depends on an underlying 'substrate', which he suggests cannot be seen as an equivalent to a social network (Watts, 2004). However, it is interesting to consider Kleinberg's work in conceptualising the information foraging effect attempted by those in the early emergence of the CoE.

More recently, Newman suggests that how nodes operate in social networks in relation to 'space' is a relatively new field for network science (Oxford Internet Institute, 2016). The challenges of 'information foraging' in the institutional environment, only to find that you are 'bumping up against the substrate', concurs with the conceptual challenge of the institution noted by Stafford Beer: "… the structure and organisation of the contemporary university … is an *iron maiden* in which scholarship is trapped" (Stafford Beer in Maturana and Varela, 1972, p.64).

Kleinberg interprets his model in terms of its potential impact in sourcing information that "... when long-range connections are generated uniformly at random, the result is a world in which short chains exist but individuals, faced with a disorienting array of social contacts, are unable to find them" (Kleinberg, 2000, p. 845). Weick defines a similar effect in his work on contextual rationality as a type of 'cosmology episode.' He describes this as "... feeling like vu jàdé - the opposite of déjà vu: I've never been here before, I have no idea where I am, and I have no idea who can help me" (Weick, 1993 pp. 633-634).

However, narratives of 'forming' or 'finding' the CoE networks note shortcuts to relying on the institution as an information source. Kleinberg also notes this 'sensible network' which gives "... global knowledge of all connections in the network, the shortest chain can be found very simply" (Kleinberg, 2000, p. 845, after Corman et al). Structurally the CoE also overcomes its institutional challenges by 'plugging into' or, more typically, duplicating the institutional machinery. These narratives are largely around wrangling, not CIs, but institutional work. The effect of the institutional environment is similarly noted when node administrators and administrative roles able to work on behalf of the CoE are in deficit:

'...two of our nodes don't have admins which has … made it a little bit challenging I will admit. We certainly benefit ... if we loop the node admin in and get them to kind of rattle the cage' PL23.

Importantly, the ineffectiveness of the 'substrate' as a point of information exchange can appear persistent. This suggests a 'cognitive' separation between the CoE and the HEI, as per the comment noted earlier:

'... at the end of eight years I'm still not convinced [the faculty] actually understand what a Centre is (laughs)' PL8.

This aspect of self-organisation or institutional design by the CoEs is valuable to understand. Centre Leads apparently successfully orchestrated the CoE within a largely ambivalent and non-responsive institutional environment. In terms of the CoE as a Janus observer, this effect is particularly noted when the CoE becomes a relatively stable form while the 'institutional field' is seen as an ever-changing 'flow' of new personnel. Although the CoE invests its own resources to leverage institutional functions, information channels can move via the CoE network and the ARC when needed. Over time the CoE information ecosystem was described in some narratives to serve as a 'work around.'

Another view is that the institution effectively benefits from the added resources and institutional work carried out by the CoE. However, what Boardman and Bozeman (2007) explored as 'role strain', appears, in the case of the CoE-HEI relationship, to be closer to CoE participants experiencing a general institutional ambivalence. I look at this in more detail below.

5.5.2   Institutional distance - experiences of ambivalence

Although 'distance' is a key attribute in visually representing social networks, such visualisations risk suggesting a topology of a set of data as a physical reality. The CoE narratives revealed both expected and counterintuitive findings about what distance means.

A number of narratives closely echo Bourdieu's concept of "habitus" (Bourdieu, 2002, p.15). In the case of the CoE in the institutional environment, this aligns with a description of: "… the perceiver ... establishes what Bourdieu calls an "ontological complicity"— to take advantage of [and make sense of their relation to] the pre-existing structural principles of the social order" (Martin, 2003, p.39.) In terms of the administering core of the CoE, distance can be considered where narratives suggest a relational 'space' as a notional form in the 'institutional field.' For example, narratives where participants

describe the time it takes to walk from the CoE's administrative 'home' to the institutional 'centre':

> '... we have enough space … but it's not ideally located, so it's a 10 minute walk from the [faculty]' RL16.

or where participants note their relative distance within the institutional physical environment:

> '... we're nominally within [Faculty A], but I've never been in the [Faculty] building' PL10.

These perceptions of distance could also reveal a form of the core-periphery effect, where the CoE sees itself in relation to the institution. In a network sense, this could also be seen as a perception of 'centrality' or 'proximity', often regarded as an important variable in understanding inter-organisational relationships (Bonacich, 1985). Dodds et al (2003) handle social distance in their modelling of multilayer organisational networks by assuming a level of hierarchy between existing nodes (superiors) and additional links to new nodes (subordinates). However, the rich descriptions in the narratives mark these as paradoxical, sense-making views, rather than measures.

This perception of distance may also differ to mathematical efforts to capture network distance to resources, which often makes assumptions about self-interest and game theory, ie "…when node R's geodesic distance d to the nearest alternate resource is small, it is more willing to share than when distances are large" (Hexmoor, 2015, p.86).   In qualitative terms, Martin describes the 'field theory' view - of space distance in terms of valence – (whether the rat is attracted to the cheese or the cheese attracts the rat) as evidence of "indeterminate relationships" (Martin, 2003, p.19). As CoEs are granted generous research funds relative to other schemes, we might assume attraction to resources, at least during emergence, is not an overwhelming factor in perceptions of distance by those in the CoE.

However, there were numerous examples in the narrative where proximity to power, or at least to the central actors who act as proxies for access to resources, were noted. For example, the Deputy Vice Chancellor-Research (DVC-R) was a prominent actor in the CoE narrative, whether for their eminence or their absence. The proximity to the DVC-R for resource negotiation was described clearly in the case of a second iteration CoE:

> '...we had to engage with each of [the prospective partner] DVC-Rs and say ... would you commit some of your matching funds to your researchers?' PL14.

The perceived distance in the CoE-DVC-R relationship also signalled their relative importance as a conduit to the institution in terms of recognition, from:

'... you know we sit under the Division of Research here so our line goes up to the DVC-R' PL14.

in contrast with:

'... we're doing some really good things … we're happy to share … (but) I would say we have zero visibility from within' PL2.

For other cases (and this would be the prominent case in the post COVID19 environment) individual leaders work entirely virtually and there is limited notion of a physical location of the CoE, so distance between 'the CoE' and the physical institution is not a consideration. Although there were comments on the work needed to bridge East coast vs West coast travel and time differences - the distance of working across Australian institutions geographically was not typically relevant.

However, narratives also provide a sense of distance *within* the CoEs which then related to CI engagement and 'the ease of working' with particular institutions:

'… We have our problem children as all Centres tend to do, in terms of we have certain CIs and institutions that are harder to deal with than others, just based on … individual personalities, **but also on how the institutions operate**' PL10.

These challenges were also linked in some narratives to institutional maturity and experience in the CoE Programme, as noted:

'... actually, it's probably not really necessarily how they operate but more how they view us or how they understand how their particular couple of CIs fits into our Centre' PL10.

and

'... so, I knew as soon as I went in there that it was a problem, but it was actually hard to get anyone to even pay any attention to it. That's one of the issues I think with being a CoE, that, particularly [at Uni1], where they didn't have any previous experience with a CoE' PL19.

However, there are also examples of 'distance narratives' which took on a paradoxical nature beyond a general frustration of dealing with the institution, and I outline these in more detail below.

5.5.3 Expecting the unexpected - boundary events of the CoE-HEI

Another odd perspective of distance was 'institutional ambivalence.' In social network terms this is slightly different to the case where there is some level of active, if unsuccessful, efforts at information foraging by the CoE, as discussed earlier in relation to Kleinberg's model. In social terms, Winkler looked at the "cultural distance paradox" in inter-organisational networks, finding "... no clear linear relationship between cultural nearness and success of a network relationship" Winkler (1998, p.307). This seems to also be a factor identified in this study. For example, the cultural nearness of CoE Leads to the executive of the 'host' institution did not necessarily relate to the level of 'comfort' the CoE experienced in the institutional environment. Even experienced Research Leads who enjoyed a very close association with the institutional or faculty executive, could relate a similar sense of institutional ambivalence as a more recently appointed Professional Lead.

The narrative by some CoEs approximates a case of Borel's paradox in the institutional environment – as related in the theme: '... if the VC even knew where the Centre was it would be a miracle.' Borel's Paradox describes the apparent paradoxical case as "expecting the unexpected" or the "equivalent event fallacy" (Proschan and Presnell, 1998). Borel's fame was to push probability to its limit - to the point that the probability of an event becomes zero (Proschan and Presnell, 1998). In the CoE case, while there may be an expectation on the side of the CoE that the VC *might* take more notice of the CoE, the probability from the VC's perspective, of (say) visiting the CoE could approach zero. Of course, a visit by the VC to any 'operational' unit of the institution is likely to be an extreme event which could raise a sense of alarm.

This experience can also be conceptualised as network reliability. Singpurwalla and Swift (2001) demonstrate Borel's paradox applies when the reliability of an event results in different outcomes dependent on conditional probability between equivalent network modules. For example, when (say) the senior group of the CoE sees itself as equivalent to the institutional executive, but that perception is not reciprocated. In this case there is a (perceived) loss of reliability across the network (on the part of the CoE), while the institutional executive experiences no such loss.

Affective outcomes of this case are interesting in social networks. Once again these can be interpreted in relation to Bourdieu's social construction of space. Over time, even the expectation of a more reasonable event - say a visit by the DVC-R or the Faculty Dean – becomes fatigued when the institution doesn't reciprocate or act where equivalence is expected:

'... I think they kind of knew we were there, but nobody ever took much interest in what we were doing most at the time' RL20.

Paradoxically, this expectation is resolved over time as a positive:

'... I guess they trusted us to get on with it and we were well resourced to do what we did and so that was actually the right way to go' RL20.

or at least becomes reconciled as simply a paradoxical case:

'... I think we flourished because of it, you know it's kind of weird - that's the only word I can use, I'm not being very helpful, am I? It was a weird relationship, but it did help us.' PL5.

These narratives are important. Firstly, they dispense with any sense of any natural inter-organisation interactions as fundamental to the HEI-CoE relationship. Rather, the HEI-CoE can be seen to act closely to Whitehead's ontological view of asymmetric spacetime events. This relational ontology provides a helpful means to understand the CoE in relation to the HEI environment. Of interest too is whether such events – or non-events – and experiences have any lasting effect on the way the emerging CoE might subsequently self-organise. In the case of two CoEs which most distinctly described experiences of institutional ambivalence or distance, we can also see the paradoxical case of the CoE becoming more culturally focussed:

'... And then we were all in the same building with kind of no-one else around and **that reinforced the culture a lot**, but we really had kind of minimum contact with the University' RL16.

and

'... it's quite good space and it actually allows us to **form a bit of a club here**, and I think that's good for morale' RL16.

This narrative of an ambivalent HEI environment feels something like Harlow's bleak experiments of the relative importance of comfort over resources. In Harlow's study baby monkeys were found to prefer the warm environment of a blanket covered surrogate over the wire cage 'mother' where milk is available (Harlow et al, 1965).

Considerations of the emotional aspect of organisations becomes apparent in these cases of dissonance and resolve. Voronov (2014) discusses this field of emerging interest as part of 'emotionalizing institutional theory.' As shown in this study a wider institutional lens and consideration of paradoxical cases from a network perspective, offer the means to capture these psychodynamic aspects of the institutional environment.

Paradoxically, the overall outcome of ambivalence and evolving cultural distinction of the CoEs, may have had wider benefits. Clearly no-one wants daily incursions from the institution and a view of institutional distance was also described as a positive:

> ' ... and I know some of the Centres at [Uni2] had that as well, where the host university was being really difficult, and ... I'm feeling so lucky that actually we didn't have that, so there were real benefits to being just hosted' PL5.

This analysis suggests CoEs as network-like organisations could set their expectations on both incursions, in terms of relative network reliability, and excursions, in terms of the likely value of network foraging. In the section below, I look in more detail at the reverse phenomena of strange forays from the institution and the unlikely percolation of policy from the Centre back into the institutional field.

5.5.4 Distance and antidotes to institutional work

The aim in exploring 'network narratives' also considered whether the CoEs are distinguishable as "... distinctive prescriptions of the collective purposes … and ... how those collective purposes should be organized and accomplished" (Greenwood, Hinings and Whetten, 2014, p.1214). From a network perspective, the CoE cannot be considered as the classical nationalised 'organisational research unit' nested in the "research economy" (Geiger, 1990, p.16), nor do they comply to the view of a quasi-firm where 'star' researchers design and then manage an 'efficient' "... intellectual framework that they wish to institutionalise" (Etzkowitz & Kemelgor, 1998, p.280).

The findings also demonstrate CoEs cannot be viewed as steady state entities which simply 'plug into' the institutional machinery and establish themselves as a subunit of a 'lead' HEI. The apparent distance between the CoE and the HEI also suggests the HEI doesn't actively engage in any "symbiotic" relationship in inter-organisational terms where "... members co-evolve with the system" (Autio and Thomas, 2014, p. 208).

As noted above, the CoE can be seen to be challenged in the institutional environment, but narratives also describe how the CoE resists institutionalisation by creating distance from the institution. In most cases the 'small world network' of Chief Investigators (CI), who progress the CoE through to its implementation, are not galvanised by the idea of institutional work (particularly if that involves an encounter with lawyers). The activity of the Professional Lead upon appointment can be seen as meeting a challenge for

the CoE to 'plug this gap' in institutional demands and navigate the early period of development:

> '… we had a [Professional Lead] who … was just a whiz with numbers and with systems and helped us … navigate through a lot of difficulties which otherwise would have just been unbearable, and we probably would have ended up with a very baroque system' RL17.

However, from this common starting point the CoE narratives take very different turns. Narratives of second iteration CoEs have something of a natural head start. These can reconfigure incrementally – and institutionally - through a 'lessons learned' approach. This follows DiMaggio and Powell's suggested isomorphic effect of the professional role. Narratives include looking at how other CoEs set rules and specifying CI roles and re-formalising governance arrangements which might 'work better' second time around. However, CoEs don't 'operationalise' in any institutional sense by focussing on 'institutional work.' Culturally, the ontological commitment/precedence of science remains evident in most narratives. For example:

> '… and we do that sort of boring administrative stuff in the morning and then reward ourselves in the afternoon by talking about research' RL17.

> '… and the administrative role (of the node leader), which is looking after the administrative aspects of the Centre, which is - somewhat about budgeting … and a lot of reporting stuff, which is - you can tell by the look on my face, what I think about that.' RL4.

The shift in offsetting institutional work is actively pursued. For example:

> '…When we first started in year one of the Centre, there was a fortnightly executive management committee meeting … But we discovered over time that - the management of the Centre didn't need that much energy as the science of the Centre needed it' PL7.

As noted earlier, CoEs also demonstrate a level of network-like capability to radically change their governance approaches. CoEs can experiment with governance, reconfigure the CoE by adding or changing institutional partners as CIs move and adopt 'whole of CoE' approaches to resetting the research agenda. These findings demonstrate that the CoE Programme does not necessarily follow a path toward institutionalisation, either via a prescribed way of self-organisation through the ARC Programme, or through any particular mode dictated by the administering institution.

However, a number of changes are present which may impact on CoE autonomy and its potential to self-organise. The CoE Programme has increased in complexity as new CoE cohorts are expected to be constituted by more HEI partner institutions and to formally establish a growing array of external partnerships. A consequence can be a subsequent challenge to retain CoE cohesion. Positive feedback effects are also evident in some cases where responses to 'what do with the CIs?' can relate to wrangling CIs (for example) which could result in further rule setting, which may in turn further institutionalise the science goals of the CoE.

In some CoEs faced with this challenge of scale, the response has been to design a highly democratised organising form:

'… (We) use 2 term max for Committee membership to allow potential for turnover and to maintain momentum. [Committee] volunteers and executives make decisions – we like to have decisions by consensus' PL23

and

'... I think we are capturing the input of those groups … I like to do things by consensus' RL21.

Institutional demands to increase external partners, may also be counter-productive. Elaboration of starting 'rules' for CoE includes international partnership formation. However, narratives suggest this adds substantive institutional work onto the CoE. The value of such partners is also not seen as necessarily adding value to the CoEs. In lieu of formalising 'institutional style' partnerships, narratives describe work-arounds to enable more informal active international connections. The 'congestion' load of adding international partners to the network may also create challenges.

'…So early on I think we weren't global enough and it was just, we were spending enough of our time maintaining connectedness just to run' RL3.

There is possibly also a challenge given the expectations on CoEs to attain greater scale, particularly those in second iterations, and to span and support ever increasing networks:

'… I think international partners was one of the things we struggled with, … keeping them engaged, giving them the right amount of information, not swamping them with too much, but also making sure that they didn't feel neglected' RL20.

This finding is of interest as it demonstrates a disconnect between the institutional logic for reputational value of 'having' high status, recognised partners, with the CoE's interest in this as a relative value. Almost all participants, when asked about their response

to the global versus local ambitions or orientation of the CoE, related their actual challenges in establishing or sustaining formalised international partnerships.

A counter example is worth noting from the narratives. The partnership with LiGO, as a National Science Foundation funded facility in the US, was noted as a partnership with '…few strings attached.' Unlike other major science facilities, such as the Square Kilometre Array (SKA), where co-investment and inter-government agreements then formalise processes for access, LiGO operates under a light MOU across its membership organisations.

One comment about non-constrained scientific collaborations, rather than perhaps more formalised arrangements based on institution-institution arrangements, notes its idiosyncratic nature:

> '…And it's (laughs) a funny collaboration, it has its own unique way of operating and it's got some well-established ways of communicating and structures that people ... that are part of that collaboration … just assume that that's the way you do things' PL23.

This 'view of the outsider' of the organisation of science chimes with similar cases of perceived separation between the 'institutionalised' and 'autonomous groups.' Mabey and Zhao's study of the ATLAS collaboration within CERN, also notes highly localised networks despite ample technological capabilities for cross collaboration across science groups. Despite a highly institutionalised system, they note a level of "… stubborn localisation" which they proposed adversely affects information exchange and team diversity (Mabey and Zhao, 2015, p. 47). Wagner also provides a paradoxical example from CERN. She notes how teams compete and 'join' at country level to have time on the accelerator. A country representative liaises with the CERN administration while a distributed team starts to work on the project - so that "… CERN may be viewed from one angle as a hierarchy, but … networks exist within and around it" (Wagner, 2019, p.100).

There are some similarities at an institutional level with the case of Xerox and its research innovation arm PARC, which were both physically and - over time - culturally separate. Like the HEI, Xerox was unsure how to leverage value from its more innovative subunit (Papachroni, Heracleous and Paroutis, 2017). These cases are interesting in considering the functional role of the CoE as an effective global intermediary. That is, the CoE – again considered as a hub in the network sense – offsets the effects of both high institutional logic and the effects of stubborn localisation. This conduit effect was well described in the narratives. In the next section I look at how the CoE narratives describe how the 'incursion' of the CoE, as envisaged by Davis and Marquis (2005) as a case of

'newcomers to the market', could also explain evolutionary effects in the institutional environment.

5.6 Moving the dial in the institutional field - the CoE effect

The reverse case of expectation was noted in narratives where the CoE raises the attention of the institution. Having perhaps become resigned to benign neglect, when someone from the HEI *does* make a random foray to the CoE, expectations are also challenged. These events were typically narrated with bemused surprise.

'… the - Manager - I think, from the [administering] School … came across and introduced [themself], which was really nice because – you know we'd never met anyone from over there and [they'd] never met any of us. And – yeah we said we'd keep in touch and we haven't (laughs) PL10.

Of interest here is what happens when the Janus object becomes the object of interest. The observed starts to notice the observer. In this case we also see unexpected outcomes. We might account for this as CoEs attain a level of growth - 'bubble' – and activity - 'boil', they naturally attract more external interest. At this point we could consider that they attain both emergence over scale in a complex system and start to make an 'incursion' into the institutional field (Davis and Marquis, 2005).

For the case considered here I look at the incursion in the case of CoE policy-making. That is the maverick view as noted earlier

'… if someone hasn't set the rules, CoEs can kind of set the rules themselves' RL6.

5.6.1 The power of percolation

For the period studied (2011 - 2019) there was an apparent policy vacuum within Australian HEIs in relation to equity and diversity. As suggested in the narratives, this area demonstrated a clear case where the CoEs actively and independently '…set the rules.' Contrary to passive views of diffusion of information and adoption of practices and processes, for CoE policy to influence an otherwise ambivalent institution something interesting is happening.

In network terms, the example of gender policy being adopted by the institution is equivalent to a 'percolation transition' event (Calloway, Newman, Strogatz and Watts, 2000,

p. 1). This approach has been used to test disease transmission, as well as at the threshold point where a 'node' becomes a distribution point. Unlike diffusion where there is minimal barrier or resistance to (say a 'downward or sideways') transmission of information, percolation suggests the transmission must overcome a threshold. Although this is modelled in disease transmission – the jump to start a pandemic for example - the model allows for potential to be considered in organisational terms - "... in the language of network robustness, [percolation] is the point at which the network achieves large-scale connectivity and can therefore function as an effective distribution network" (Calloway et al, 2000, p.2).

The emerging theme of gender equity and diversity in science was so prominent in the narratives, that it provided enough material across the contributors to build a more substantial network picture of the ways CoEs navigated institutional policy. In addition to policy, CoEs also created independent forms of governance, established strategic goals and implemented new initiatives around this challenge.

These indicate the flexibility within the CoE environment to the extent of undertaking policy experiments:

> '… I guess our hands aren't tied quite in the same way as a person within the University solely is in trying to do this. So, we can set some of our own policies that are above and beyond what the University's expectations are. You know we have our own - Gender, Equity and Diversity Policy' PL7.

There was no prompt question in the study related to gender or diversity. However, this theme was volunteered in some detail by 12 of the interviewees (6 men and 6 women) in relation to 8 different CoEs. This highlights three areas of interest. Firstly, that the self-organising potential of the CoE extends to more universal policy development opportunities and secondly that the CoEs collectively can act to shift institutional policy. Narratives also describe the legacy value of these policies flowing into the field of science.

By drawing the narratives together from this theme, I was also able to create a picture in relation to the Janus model. As shown in Figure 5.3 below, I note the points at which gender and diversity policy was described in relation to the institutional, the CoE Programme or the wider network (field of science) environment. The cycling of policy, which then 'crosses the threshold' into the institutional domain, demonstrates evidence of both autonomous self-organisation and cultural development within the institutional environment.

Of particular interest was that CoE policies gained the attention of the institution. Given, as noted in the findings, the institution paid very little attention to the CoEs, the potential for this to raise their interest is worthy of further consideration. Of relevance is an indication that the CoE can indirectly enable the co-evolution of the institution. From an

institutional point of view the 'multiversity' effectively levers its "…accumulated parts and functions" to increase its "…social weight" (Marginson, 2017, p.252). The importance of this proposition is that the accumulation of CoEs could serve a value to the institution, in this case, through its organising potential, rather than directly through any research output.

A more institutional view of this policy imperative within the CoE, might be the pragmatic demand faced by CoEs to recruit a relatively large number of postdoctoral fellows into the programme from a standing start.

> '... and from then on the main imperative was to recruit and start to build the Centre up, - and you know recruitment, particularly in our area where talent, it's - quite competitive to get talent' PL19.

However, setting recruitment policy was an area CoEs also had flexibility and leverage over. That is, they had discretion to allocate funds in relation to their own policy and could vary or add to the policies set by the HEI. Interestingly, here the CoE can be seen to be 'managing up', rather than being the recipient of coercive institutional effects.

> '… we've put … nearly 90-100k per annum into various initiatives … as well as going to the Universities and asking for 'we'd like our next permanent hire to join the department to be a woman, please' …' RL11.

> '… and our recruitment policy, I hope actually had some tangible, positive benefits in terms of improving the gender balance of our recruits' RL23.

Navigating a hybrid set of rules across the HEI partners is nevertheless complex. Where legislation exists workplace requirements are clear, such as for sexual harassment management. However, grey areas, such as extending childcare provision for researchers, is where the CoEs either add flex through CoE level policy and funding or are constrained by the multi-partner institutional 'rules' which don't accommodate such a provision.

In Figure 5.3 I capture the spectrum of policy influences that are both imposed on the CoE but also, where policy is generated by the CoE, to see how far this might travel. As per ARC's contracting arrangement, the CoEs must work within the policies established by the partner institution. However, the potential for organisational design and institutional evolution through the actions of the CoE are valuable insights into the HEI-CoE relationship.

Figure 5.3   Policy generation and percolation effects of the Centre of Excellence
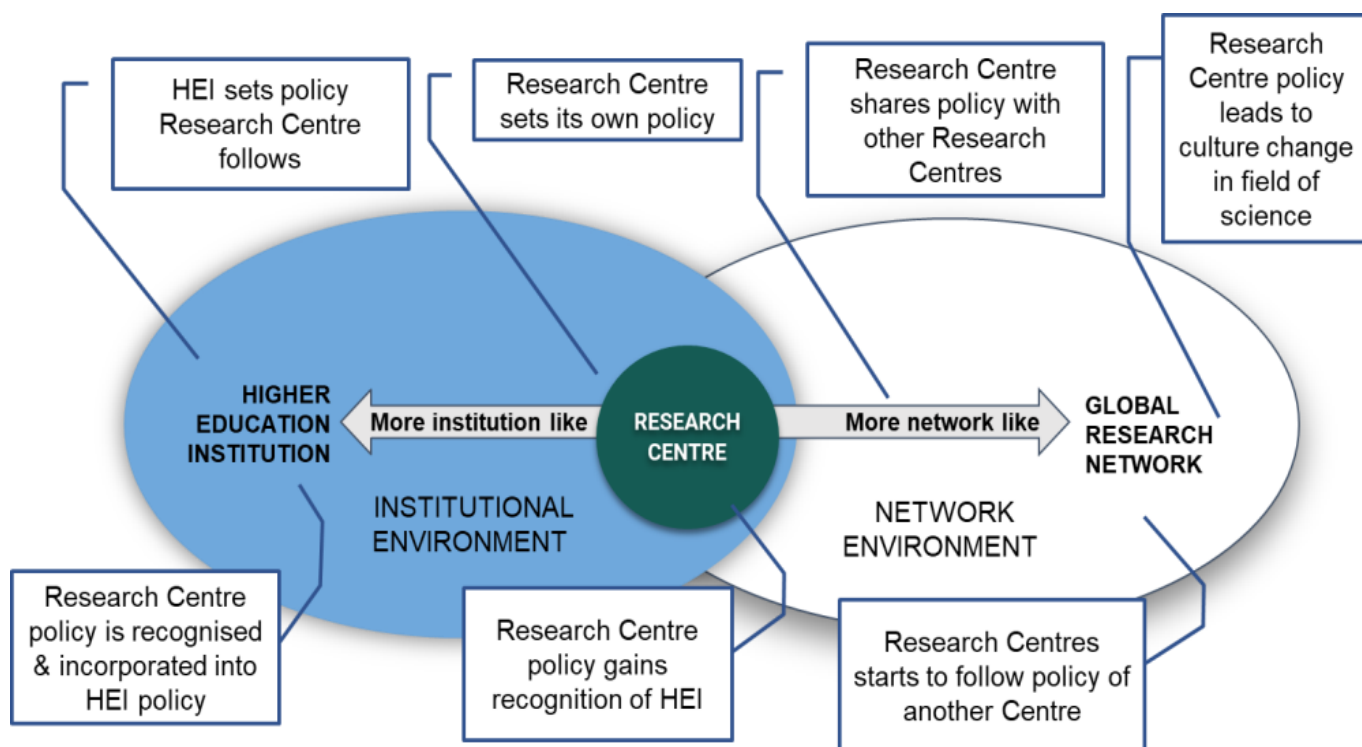
5.6.3   Matthew and Mathilde

The consideration of diversity in science is a point where two concepts of institutions meet - the larger social institutions of gender, race and class (Tracey and Smith, 2017) and the more tangible evidence of participation in Higher Education research. However, another finding, not elaborated on in further detail here, may be the relatively younger demographic of the CoE to that of the institution. However, narratives strongly note the roles, governance arrangements and advocacy potentially enabled through CoEs which actively support generational diversity.

The loss of women from research roles in HEIs marks pervasive institutional effects. This was described by one contributor as the 'leaky pipe' in relation to the way women 'leak out' of science leadership opportunities. In parallel, the increase in women in research professional roles who hold post-doctoral qualifications is noted globally (Scott and Kerridge, 2018) and some of the benefits of this effect has been noted in studies of professional roles in Australian HEIs (Berman and Pitman, 2010). This offers an interesting social dynamic of a new paraprofessional role with a classic gender divide. Apart from the social equity interest, why is gender in western science such an issue?

Network science has focussed interest on the phenomenon of network growth and preferential attachment, which was first described by Merton (1968) as the Matthew Effect *"For everyone who has will be given more."* This fundamental concept in the ongoing expansion in the sciences and the association of scientists in particular fields, based on co-publications, is demonstrated by Albert and Barabási (2001) in their description of the scale-free phenomenon of 'true' networks. In network terms, *preferential attachment*, notes the phenomenon of certain nodes in a network becoming disproportionately connected resulting in a pattern of 'giant clusters' which approaches the power-law in nature (Barabási, 2009).

In the case of science collaborations and network formation, Wagner notes the Matthew Effect is seen when "…well-known scientists tend to work with each other across institutional and political boundaries. This makes sense in a self-organizing networked environment operating under rules of preferential attachment" Wagner (2018, p. 90). Institutional factors, such as incentives, norms, rules or other constructs within a system may have an impact, for better or worse, on network formation. What we ultimately 'see' in the output of social network analysis is only one of many potentials which could be driven by institutional settings.

A history of the exclusion of women in western science, from attendance at universities to exclusion from the Academies of Science in western Europe up until at least the mid-20th Century, sets the societal background of institutional challenge to admission of women to fields of science by men (Jones, 2019, p.239). In the case of Marie Curie, the institutionalisation of gender first excluded her from study at Krakow University and later from speaking to her findings at the Royal Institution in London in 1903 (Pasachoff, 1996).

Counter to the Matthew effect, the 'Matilda Effect', first named by Margaret Rossiter after the suffragist Matilda Gage, signifies "… a systematic under-recognition of female scientists" (Knobloch-Westerwick, Glynn and Huge, 2013, p. 604) and its effect has been documented in the case of researcher, Mathilde Vaerting who tested the institutional structures of her day by publishing under a male name (Gliboff, 2018). Empirical studies have also demonstrated the Matilda Effect as persistent phenomenon through under-representation and bias effects toward women in western science (Knobloch-Westerwick et al, 2013).

Of interest from the view of institutional theory is the way the 'science role' is viewed as "… agentic and masculine", whereas women's roles are viewed as "… primarily communal" (Knobloch-Westerwick et al, 2013, p.607). CoEs are seen to be able to vary

this mode, where communal gender-neutral roles can be set as the norm. As one participant noted:

> '…and you'd see people who were high achievers but who were nice people and would take time out to take care of their family … and [that] became more explicit over time, because people became more comfortable talking about this' RL20.

This demonstrates a remarkable potential to reset norms in relation to the dominant institutional logic within the short time-span of the CoE.

Given systemic effects in the science ecosystem, gender inequity can become amplified. A study by Dion, Sumner and Mitchell notes that, even in the social sciences, an ongoing effect of preferential attachment skewed toward male 'authority', in that "... women's research will be cited more frequently in disciplines with higher gender diversity, but men's research may still be treated *as the most central* or important research in those areas" Dion, Sumner and Mitchell's (2018, p. 316).

Perhaps unsurprisingly then there appears to be much more written about the Matthew Effect in the field of network science than the Matilda Effect. Given a favourite pastime of network scientists is to remove nodes from the network and see what happens, the Matilda Effect would seem worthy of some modelling. However, one reason for a lack of real interest in considering the Matilda Effect in the 'big sciences' is an understanding of the high robustness of the scale free network.

Models in the globalised fields of biological sciences and high energy physics, suggest that you can remove "... more than 80% of the nodes in the network without destroying the giant component (the highly connected nodes) — and the network will still possess large-scale connectivity" (Calloway et al, 2000, p.3). Conversely, the network can be fragile, in the case of removing the highly connected nodes (Calloway et al, 2000). Institutionally, the sustaining of these highly connected nodes, through awards and so on, can also serve to sustain the established network.

Other recent studies of funding effects, including Hechtman et al (2018), and further comprehensive reports on gender in research Elsevier (2020), are drawing greater attention to the cultural divide in science. These appear to highlight the institutional effects of westernised science which are not evident in Latin America and southern Europe.

Modelling on 'network trimming', such as those by Hu et al (2016), could serve as a useful proxy for exploring the Matilda Effect in social studies of science. These models assume the effect of node removal in the case of machine learning will serve to make a network 'more efficient.' However, when Hu et al (2016) test node removal they identify consequences for 'network learning' and effects of network isolation. This method could be

applied to consider the ramifications of premature 'removal' of women in science. Of course, the removal of any well-connected node means the subsequent *potential* to form a central hub in a scientific community is lost, as is the local network connectivity. However, Hu et al (2016) also note a 'learning' deficit which arises with node removal. In this case isolated nodes or new nodes (say 'new researchers' entering the research system) have to relearn what is lost if they become disconnected from a former node.

Another important shift in culture is becoming more evident in ways that might appeal to institutional logic. All Australian CoEs are highly productive in relation to their collaboration achievements – such that 22 of the 30 CoEs active in 2014 were recognised through their collaboration scores in the Nature Index. However, one CoE, which was also the most proactive in establishing gender equity and cultural change policies, achieved one of the highest collaboration indices across all international collaborative centres and institutes (Nature Index, 2015).

The leading world institute in the Nature Collaboration Index in 2014 – the Kavli Institute for the Physics and Mathematics of the Universe (IPMU) – also noted the important role of culture, with the Director insisting in a battle with the funders for mandatory staff tea time as a tool of choice in collaborative effort. "… I don't think taxpayers anywhere like to pay for tea, but I knew that it was worth fighting for" (Nature Index, 2014, p. S80). This social aspect of 'talking about science', noted as a distinguishing act of scientists by Mohr and White (2008), has not always been valued as a critical aspect of scientific endeavour.

Part of the narrative for those engaged with CoEs which had formally closed, was the CoE legacy in relation to quality, equity and diversity. By documenting their change processes, participants emphasised how the CoE was also able to socialise this work to other parts of the research system. This effect of 'changing the dial' in the institution and normalising an approach to work-life balance represents a potentially powerful socialising role of the CoE. The role of gender equity in community structured networks is an interesting one which might be open to further study. In terms of the information values of the CoE, having a 'paired system', with two leads able to support and engage in policy development, may be an important component in enabling change. This two-way approach of supporting diversity more broadly through pragmatic, cultural and policy means demonstrates a highly engaged effort.

This establishment of the CoE as 'a cohesive network' also suggests that, apart from distance and number of those engaged, the culture of science works best when it retains a

sense of the 'salon', which goes back at least to the time of Mary Somerville (Secord, 2018). However, such findings – that the science group is a loosely formed type - can be resisted in 'modern science.' A question then is whether an understanding of modelling from network science can support a bridge between an empirical view of 'science at work' and the sociological perspectives of how science is constructed? In the next section I want to consider what this looks like in terms of network robustness at the CoE level.

5.7   Network Effects

> "... Considering the blundering anarchic system of the United States, the stupidity of some
> of its lawmakers, the violent reaction, the slowness of its ability to change. Twenty-five
> key men destroyed could make the Soviet Union stagger, but we could lose our congress,
> our president and our general staff and nothing much would have happened. We would
> go right on. In fact we might be better for it."

<div align="right">Steinbeck and Ricketts (1958) From the Log from the Sea of Cortez.</div>

An interesting case in the formation of CoEs is whether the established network-form provides long-term robustness. The interesting effect of the core-periphery model resonates with the prescient observation by Steinbeck on the relative fragility of the USSR compared to the institutionalised governance system of the US which we witnessed being actively pursued and tested for its relative robustness in January 2020.

How we understand these processes may also be important in shifting vocabulary, away from the concept of the CoE as some 'start up entity.' In the case of the CoE study, adopting terms offered through the narratives was particularly relevant. We can then note how CoE 'network narratives' respond to the institutional environment, to map a complex systems view of emergence.

Complex systems models which consider emergence (after Bruno, 2009) can be applied to consider the CoE case. In Bruno's model these first define 'ambiguity', where spatial relationships are processed. This is followed by 'uncertainty' which follows the contextual challenges of information foraging for those navigating the institution. As the CoE establishes, coherence is recognised. Finally, emergence is evident when the institution

pays attention to the CoE, which is seen in the case of the HEI's interest in the CoE's development of novel gender and diversity policy.

5.7.1 Network robustness - transitions through emergence of the CoE

At a more local level, formations which assure a level of robustness may be an important consideration for CoEs through transitional phases. The 'typologies' suggested from the narratives in Figure 5.2 suggest the formation of the CoE has the potential to adopt structural choices to 'enact' the CoE. Of importance to note again is that CoEs from similar fields of science demonstrate different narratives in their formation, and, conversely, those from different fields can appear similar. CoEs in the same host institution can also have very different formations and experiences of the institutional environment.

This raises a question of whether the formation of the CoE and the experience of the macro institutional environment, somehow impact on its subsequent formation. As shown in Figure 5.2, there are a series of transitions which may relate to particular network-like forms. In a 'model CoE' these would be 'the small world of the CIs', the expansion to a 'core-periphery' model as CIs interconnect with respective teams and then the fusion over time to a 'multiscale' network. Throughout these periods the institution has an effect, as discussed, in imposing institutional work. However, over time this generally lessens, even to the extent that the CoE can be proactive in replicating the demands of institutional work and creating recruitment policy.

In addition to these more formal organisational archetype models, narratives by some CoEs relate closely to a community structure network (Girvan and Newman, 2003). In other cases, CoEs seem to be challenged to establish or sustain a level of coherence. I briefly consider these two contrasting cases below.

5.7.2 Betweenness and information flow in the cohesive community

As invaluable as it would be to observe a CoE throughout its seven-year lifespan and make note of the interactions of its members – this type of anthropological study is unlikely to gain much traction by either funders or participants. However, the seven-year study of the dolphins of Doubtful Sound by Lusseau et al (2003) offers remarkable insights into the actual function of a community network. When Girvan and Newman (2002) used

this data to support their community structure network model, they were able to demonstrate a close fit to the types of sub-groups they had modelled for such a network.

By looking at measures of betweenness, defined as "a measure of the influence of individuals over the flow of information between others" (after Freeman, 1979), Lusseau and Newman were able to demonstrate that "... a small proportion in the tail of the distribution are much more influential and may be regarded as key individuals who can control the flow of information in the society" (Lusseau and Newman, 2004, p. S479).

Lusseau and Newman conclude that particular individuals with high betweenness - who they note as equivalent to information brokers in human societies - probably occur in bottlenose dolphin societies as well (Lusseau and Newman, 2004). In analysing the role that individuals play in their social networks, they also identify 'brokers' who act as links between sub-communities and "... who appear to be crucial to the social cohesion of the population as a whole" (Lusseau and Newman, 2004, p. S480).

This attribute of 'betweenness' and influence is expressed and understood by the CoE Professional Leads network, as one participant noted:

'... rather than [the Professional Leads being seen as having a role in] research management, now we have a structure of 'network as influence' model' PL15.

This pivotal role now distinguishes a split from 'institutional work' and 'network development.' However, the 'influence' could also suggest an institutional interest which is similar to the view of the profession as shaping the institutional environment, as put forward by DiMaggio and Powell (1983). Nevertheless, this is an example of that evolution.

There are other potentials to consider from the data from Lusseau and Newman (2004), which also notes the features of community robustness. On modelling the removal of hub individuals where a co-lead pattern was observed, the overall community network was not overly disrupted. Given the strong association of the Professional and the Research Leads, the temporary disappearance of an individual with high betweenness may buffer the CoE when compared to more uni-directed systems. As one participant noted:

'…You know, I used to joke that if I went away for a year [the Professional Lead] could just run the Centre because [they] knew everything' RL20.

The CoE narratives which had other strong community focussed outcomes, describe achieving this sense of cohesiveness across the organisation and used terms that noted the formation of a community of scientists. However, if we take the growth of a wider network as

the next natural phase in the growth of the network, this is not demonstrated by Lusseau and Newman's community model. They found that, although there were highly connected individuals in the group which created a 'hub' for effective communication, there was no power law in operation which would allow the community to continue to grow as proposed by the Albert-Barabási model of scale-free networks where preferential attachment occurs.

Of interest for the community structure network, the concept of growth was more centred around the 'growth' and subsequent mobility of the researchers themselves - the potential to readily leave the CoE. These CoEs also actively removed the senior researchers from a bid for a future Centre entirely, signifying a sort of self-resetting of the 'network in the field.' They also engaged younger researchers to take on the leadership work. This signifies a maturity of the field of science in having confidence to design, or redesign its own governance:

> '... the Centre's in good hands, it's moving forward, it's a good chance to bring some of these younger people in, actually give them some experience - being on the executive and running a node of the Centre' RL20.

The other outcome was that the throughput through the leadership roles was high. The leaders, who were nurtured through this CoE structure, went on to demonstrably populate other sites in the global network. The descriptions suggest the CoE was able to actively act as a generative hub and create an ecosystem effect.

5.7.3   Network fragility – node removal and dissipation of the CoE

One group of CoEs, typically those with high levels of transdisciplinarity – that is where very different fields were being brought together to form the CoE - seemed more challenged to form a 'Goldilocks' group. All CoEs are working at the forefront of science, which means engaging in transdisciplinary science, but CoEs which are either looking to achieve high innovation goals and/or seeking to establish a new transdisciplinary field, often face additional challenges. The former may be due to formalised expectations around intellectual property (for example) and the latter because of a distance between the fields of science. This potential difference is noted in this description:

> '… So, I think for groups like mine, we do have some natural advantages in building a CoE [without IP] which I know other Centres have spent years negotiating … I wrote into the proposal 'all IP will be freely available'. And people said 'Huh? What?' And I said 'well there's no money to be made out of this. You can't make a dollar' RL6.

This finding aligns with Borlaug and Gulbrandsen (2018) who found researchers in CoEs in Sweden and Norway with more formalised expectations for industrial engagement, were *less* engaged with industry than CoEs with no such formalised requirements. Studies of new configurations of science have also considered the combination of 'star scientists' (Zucker and Darby, 1996), quasi models of the firm in research (Etzknowitz, 2003) and technology transfer modes of research engagement (Villani, Rasmussen and Grimaldi, 2017) to typically advance the proposition that a more corporate model of science organisation will 'improve' outcomes. However, in some cases these fail to demonstrate better outcomes than more traditional science groupings.

But bridging goals in distinct fields of science can also be difficult for CoEs with no IP. This suggests the 'distance between the disciplines' and the consequent structuring of the CoE was possibly just as important a challenge to overcome. For one CoE this was noted in how groupings between institutions were initially engaged:

> '…well we need to have a different approach to how these teams would be constructed, because they need to actually be multi-institutional teams rather than part of what our Centre was, … more … like well this institution brought [expertise A] and this institution brought [expertise B]' PL8.

Narratives from transdisciplinary CoEs also seemed particularly challenged in 'information foraging' beyond the CoE in the establishment phase. These perceptible, if perplexing, experiences at the beginning of the lifespan, suggest evidence of struggle through emergence on the part of the CoE. The noted increase in complexity of design of the CoE Programme coupled with the inherently complex institutional environment is likely to also contribute to these challenges. As Johnson notes in a discussion on a range of perspectives of emergence, emergence can be considered evidence of complex systems where 'surprise' events occur (Johnson, 2006).

Of interest too is to what extent the institutional environment impacts on the network formation of the CoE itself. Institutionally, transdisciplinary CoEs may be more challenged due to misalignment with a particular faculty within the existing institutional structure. Woelert and Millar observed the struggle for interdisciplinary research to 'fit' into existing institutionalised structures, noting that the "... Australian context can only be understood properly if placed in the context of a more general paradox of research governance [where the] rhetoric of innovation conflicts with the … diminishing scope for the self-organisation of knowledge" (Woelert and Millar, 2013, p.756).

The more highly interdisciplinary or transdisciplinary CoEs also described a more rapid dissipation of participants at the end of the Centre's life as activities and schemes come to a close. For example:

'… So those groups are probably … much more focussed back on I guess their expertise' PL8.

Whether a CoE can actively offset some of the many challenges inherent in interdisciplinary research should be of interest to the CoE Programme itself. For example, do early formation of 'robust' CI and Professional Groupings obviate some of these challenges? In the Lusseau-Girvan-Newman community structure model, which had a balanced form of co-leadership, the removal of a hub individual did not upset the overall network structure, but removal of a number of lead individuals would reduce the cohesion of the community network. This might be noted when the Research Lead takes a prolonged period away from the Centre and when the Professional Lead role is weakly established or leaves prior to the closure of the Centre.

However, even professors don't last forever and there are natural retirement and other points of attrition for senior leaders of science. One concern expressed for a core-periphery type CoE with very senior researchers in the core, was that an over-investment in time focussed on the CoE could mean the field of science overall 'takes a hit' in future years - as noted in one case:

'... there's a potential for a feast or famine effect where we will see seven wonderful years, ... but then during that time the very staff ... are drawn away from teaching … so we're always trying to talk about 'what are we doing for the undergrads?' ... So, we can see after the Centre ends the field takes a big hit' RL17.

This analysis of findings for the CoEs reveals a rich and interesting diverse world of organising. In the next Chapter I discuss this in relation to the literature to suggest how we can derive learnings of value for theory and new understandings of network-like forms with a focus on their 'life' in the institutional environment.

Chapter 6   The institutional life of the CoE

This research took up a challenge proposed by Meyer and Höllerer to consider the effect of "... organising collective efforts" within a context of "... complex landscapes of *pluriform organisations* in which sovereignty is fragmented and challenged" (Meyer and Höllerer, 2014, p.1224). As the Australian CoE Programme has not previously been the subject of external research, the research design aimed to gain insights into the complex landscape of the HEI from the perspectives of multiple CoEs. In turn, through exploration of narratives, both through an institutional theory lens and in relation to network science, a closer understanding of the CoEs as emerging forms in complex environments was gained.

The research also addressed Wagner's wider question whether the apparent ongoing self-organisational forms of global science networks offers a broader value "… to understanding social organisation" (Wagner, 2019, p.xiv). In contrast to the views of expanding science networks, views of potential constraints of the 'research network' within the HEI are similarly embedded. Lovink and Rossiter note the modern HEI is a site of "… quarantined enquiry …incapable of infection" (Lovink and Rossiter, 2018, p. 112). However, Mohr and White note both the constraints of the HEI and the uncontained nature of science "…the devil here is the existing, possibly ossified Establishment ensconced within separate departments of the discipline around the country. Certainly no one department is large enough to mount work on the scale of an invisible college" (Mohr and White, 2008, p.500).

In selecting the CoE Programme for this research, the CoEs, as National Research Centres, were seen to be adequately separate from the HEI. In this way, as a Janus object the CoE can be considered effective in simultaneously offering two views, one to the institution and the other to the networked environment. The CoE role as an observer object assumed that National Research Centres would be less entangled with the HEIs than Research Centres formed within individual HEIs. However, the CoE should also serve as an example of making the invisible college of an emerging field of research visible, as suggested by Bell (1996). The review of ontological perspectives of Research Centres as a relational object in the HEI environment also helped to guide an understanding of the CoE as a Janus and consideration of the experiences of 'unexpected events' in the narratives.

Throughout the research, a process of 'switching lenses' aimed to consider perspectives from institutional theory and network science to support an analysis of the network-like organisation in a complex environment. The findings of the integrative review demonstrated foundational links, through sociological studies, to support a more methodical consideration in the study of the institutional and the network. A further finding from the integrative review and the process of applying a neo-institutional lens to the CoE study, is that in order to consider complex institutional environments, institutional theory should be gently prised away from an emphasis on logics proposed by Thornton, Ocasio and

Loudsbury (2012). However, while the research follows neo-institutional theory to account for the CoE as a rational collective in relation to the institutional environment, I also note how institutional logic may serve as an explanatory concept applied to observations of 'odd behaviour' of the HEI. The distinction perhaps being that, as observer narratives suggest, the 'logic' of such behaviour may not be discernible - notably by examples such as - 'the HEI wanted to *win* a CoE (status), rather than to *have* a CoE' (institutional work).

In discussing the analysis of findings from the three studies I consider three aspects of synthesis in relation to the literature. Firstly, the evidence that CoEs meet Meyer and Höllerer's interest in pluriform organisation. As the CoE study allowed a view of emergence over three separate cohorts, I have suggested they also offer a pluripotential view of ways in which CoEs emerge and adopt particular ways of self-organising. I first considered the CoE within the institutional environment. How did this inform an understanding of the CoE as a Janus object, based on observations and experiences? I then considered the specific understanding gained from the emergent findings and analysis of the synergy through the CoE roles of the Co-Leads. Finally, I considered the theoretical literature in relation to the findings to propose how institutional theory could be moved forward through consideration of network science in forming studies of complex forms of organising. This considers the empirical findings in relation to the dialectic within institutional theory and how this marries with network science to offer new approaches to studies of 'complex designs', as envisaged by Meyer and Höllerer (2014).

6.1 The pluripotential CoE

From the findings I propose that each CoE cohort offers a pluripotential set of organising forms. On paper at least, CoEs commence stem-cell-like from a cohort with similar institutional 'DNA.' That is, they have a similar period in which they commence; a projected seven-year lifespan; similar levels of funding; similar numbers of founding partner institutions and Chief Investigators (CIs) and a grant agreement which specifies arrangements. However, as the narratives reveal, each CoE then proceeds to self-organize and, in some cases, reorganise, in quite individual ways. In looking at how CoEs emerge and interact in the institutional environment we can also see CoEs as emergent network-like forms, in line with Meyer and Höllerer's concepts of complex designs and pluriform organisations.

The analysis of findings through network narratives provided particular value in being able to describe the 'types' of pluriform CoEs. The narratives could be considered in relation to a range of network-like typologies (after Watts, 2004). The narratives suggest an array of approaches to self-organisation, leading to different descriptions of autonomy and potential for 'true' network-like forms to result. These findings help to clearly distinguish the CoE from the Research Centre as an 'operational research unit' embedded or located 'within' the HEI (Geiger, 1990). Although some CoEs may 'strategically institutionalise' in order to align with a national research agenda, they do not extend to the model of 'quasi-firms' (Etzkowitz, 2003). The narratives also do not reveal any symbiotic CoE-HEI inter-organisational relationship that would demonstrate a tacit 'ecosystem' effect in the sense proposed by Autio and Thomas (2014).

Instead the findings suggest that CoEs demonstrate pluripotentiality, which, combined with CoE 'experiences', offer views of inter-relational effects of 'types of network-like organisations' within the institutional environment. By considering network models by Dodds et al (2003) and Girvan and Newman (2004), network-like views of typologies of the CoE were also possible. In particular, these allowed views of asynchronous periods as new partner nodes or researchers are 'brought online'. From there the CoE evolves to form a 'cohesive whole' and to potentially be perceived as a Gestalt, as envisaged by Mohr and White (2008), as the point when the CoE 'blends' with the wider 'invisible college' or global network.

6.1.1   Self-organization in the CoE – from self-organising small world to a gestalt

The network narratives developed from the CoE study effectively demonstrate views of 'self-organization.' Of key interest is that different CoEs, in terms of fields of science and/or in different institutions, can adopt similar forms of organising. Conversely, relatively similar CoEs in closely related fields can adopt very different forms of organising. The groups of models developed in relation to the taxonomy of network models by Watts (2004) include: organisational models by Dodds et al (2003), who reimagine more classical organisational archetypes; the small world model of Watts and Strogatz (1999); and the community structure model by Girvan and Newman (2003). The scale-free model by Albert and Barabási (2002), derived from bibliometrics data from expansive fields of science, was also considered in relation to the CoE narratives. The best approximate models from those reviewed provided an overlay in relation to the CoE narratives which are also aligned to perspectives gained through institutional theory.

As pattern seeking organisms, we need to be cautious of concluding there is an 'true' or overtly 'neat fit' of narratives to network forms. In particular, the suggestion of 'new archetypes' needs to be avoided in an interpretation of the synthesis using network models. The models developed by Dodds et al (2003) are derived from work by Lawrence and Lorsch, which in turn were derived from manufacturing organisations of the 1960s. Despite their age, the models still have some relevance from the perspective that they "...treat variations in formal structure as *rational* adaptations to technical and environmental conditions" (Barley and Tolbert, 1997, p.93). The value of Dodds et al (2003) work is to extend these archetypes as dynamic models to test information exchange and robustness by treating them as network forms through their formative stage, that is as new nodes are added to the structure. In terms of considering multilayered forms of organising, these provide helpful additional views which align with the CoEs as 'original' forms of organising.

The scale-free model of Albert and Barabási, similarly extends the frame beyond the archetypal models used by Dodds et al (2003), particularly in considering science networks. However, of closest relevance is the potential to compare real-world models of social interactions, such as those by Lusseau and Newman (2004). The 'real-time' data of social network interactions made available from Lusseau and his colleagues, offer compelling opportunities to explore information exchange, network characteristics - such as betweenness and natural network configurations - based on observed interactions. As discussed further below, the synthesis of these network narratives also allowed for a closer

reflection on the roles of those participants in the CoEs and how their roles related to such networks.

Another aspect relates to the specific case of the self-organisation of science. Latour notes the 'place' of science production as the "…sublime production … manufactured at specific places and institutions" (Latour, 2005, p.175). In one sense he is correct, the individual researcher can only be in one place at one time, but their work is not bound in this way in an institutional sense. The CoE in particular differs from the 'classical' view of production of science within the institution. The CoE narratives note perceptions of spacetime, including the pragmatic realities, as being almost entirely a virtual organisation. Even within Australia, the transcontinental nature of most CoEs creates both challenges and solutions requiring wholly different modes of working.

Latour's other view of the oligoptica is closer to these narratives of the CoE as a whole, which allows for a network view, "… from oligoptica, sturdy but extremely narrow views of the (connected) whole are made possible—as long as connections hold" (Latour, 2005, p.181). When asked to look at the CoE from the outside, the CoE Leads can readily point to the geographically extensive network of researchers, the extent of the physical or social field of interest, the networks of research and wider collaborating organisations.

Latour's point about this view '…while the connections hold', also speaks to the relative network robustness of the CoE and its transience. Similar views of the paradoxical marriage of maintaining stability and coherence while simultaneously bringing about actions of change are noted by Zucker (1986). However, the organisation of science, as its own life form, also provides the CoE with a trajectory beyond its life course. Beyond the Gestalt of the CoE, the expansive nature of the organisation and constant emergence of science is also captured in some narratives:

> '... the field is a growing field [with] more conferences emerging in the field … so that really attracts the international powerhouses … there's just this massive cross pollination of global people and global ideas really so you just have to turn up and it just happens' PL14.

However, to what extent the CoE narratives support a case to understand any 'ontology of organising', which aligns with a complex systems view, remains challenging. Thompson's conjecture that there is no 'organisation', but only examples of simultaneously "... organising and disorganising" (Thompson, 2008, p.56), is directly evident in the CoE lifespan, both in its multiple modes of self-organising and in response to the institutional environment. Meyer and Höllerer's list of 'ephemeral forms' could also fit within a 'true' network ontology, given the array of network topologies outlined in network science by Watts

(2004). The interplay with self-organisation, emergence and the effect of the institutional environment is discussed in more detail in the next section with reference to wider studies of network-like organisations.

6.2 Casting a net over emergence in the institutional environment.

In casting a net over emerging organisational forms, we can use neo-institutional theory to explain the network-like organisation as a relational form within the wider context of the 'organisational field.' This allows a reasonable step to viewing the network-like form through a network perspective to consider emergence as experiences and responses in the institutional environment.

Why should having an ontological niche for network-like organisations matter? As noted by Lovink and Rossiter (2005), even the suggestion of an 'organised network' is an oxymoron. As a network scientist, Mark Newman notes his definition of a true network as "... an object that represents *sparse data* where most possible connections *are not* present" and its opposite - dense data "... is where everything interacts with everything else" (Oxford Internet Institute, 2016, np). However, to demonstrate that network-like organisations are distinct in nature from the institution and not merely 'institutions in waiting' we need to be clear about the distinction.

6.2.1 The CoE as an observer of the institutional environment

For the purpose of taking observations, the research design took an indirect view by guiding participants to share experiences of interactions in the institutional environment. This effort was to control for the 'observer effect', recognised in sociological and anthropological studies as well as the physical sciences. Dent's interactional model is helpful here in also allowing for relational dynamic observations, although it assumes more traditional organisational relationships (Dent, 2003, p.304). However, just as physicists may need to follow Heisenberg by 'not observing' what electrons get up to (Futura, 2012), Searle similarly suggests the best way to respond to ontological problems, such as determining '…what is an institution?', is "…to sneak up on them" (Searle, 2005, p.2).

Taking an 'indirect' view was also considered a way to gain further insight of the institution as models of organisational equilibria, structured through rules and norms

(Crawford and Ostrom, 1995) and to understand the interplay of CoEs in "...the institutional life of the organisational field" (DiMaggio and Powell, 1983, p.148). The observations also had potential to note cybernetic views of peculiarities of the HEI, such as 'strategic fads' (Birnbaum, 2000) or blackbox modes of control (Birnbaum, 1989). The proposed autopoietic nature of the institution was also presented as a potential 'reality' in gaining insight 'into' the institution itself.

The CoE narratives don't directly note the institutional logics of the HEI. In comparison, a qualitative study on a set of institutes based in a single institution in Australia noted the emphasis on 'money' and 'reputation' (Dodgson and Staggs, 2012). In contrast the CoE narratives were more perplexed, '… and the cynic in me thought the university wanted to win a CoE more than it wanted to have one', and the more direct, '... of course they're very prestigious, all universities want [CoEs] and then once they get them they don't know what to do with them.'

These observations can be inferred as evidence of reputation as an institutional logic. Clearly, 'winning' a CoE represents 'money' and 'reputation' as institutional logics. However, beyond this, logic fails. The institution doesn't know 'where to put' the CoE or how to 'assign' the CoE to any institutional framework, '... they <u>want</u> to have CoEs... but we are an anomaly I suppose' or '… we are a more complex organisation, and we don't always 'fit' the [university] guidelines.' In terms of potential for logics to result in institutional change, Mohr and White point to a range of studies which upturn the institutional logics of Friedland and Alford (1991) as a basis for change. They suggest structuration effects, as "...overlapping styles", rather than strategic, political effects, act as the source of institutional change (Mohr and White, 2008, p. 508).

Institutional reputation is also seen to have propagated the 'idea' of research excellence (Taylor and Braddock, 2007; Marginson, 2007). The institutional logics of research 'excellence' and 'innovation' have been explored with researchers within similar national science centres (Borlaug and Gulbrandsen, 2018; Boardman and Bozeman, 2007). This also provides an example of the CoE and institution being stuck with disparate, rather than competing, logics. However, competing 'values' may be more relevant to consider from the CoE side in terms of a closer ontological commitment to science. For example, Mohr and White note 'values' of science as "... the [preeminent] value in working science … is originality (a variant of scope) … and the value of truth" (Mohr and White, 2008, p.494). Although we can infer a level of institutionalisation in some CoEs narratives, most emphasise values such as 'trust' and 'capacity building', or simply 'doing science', which guide their autonomy. In a number of cases narratives are directly counter to the dominant institutional preoccupations of the HEI or the aspirations of the State.

This CoE ← → HEI dynamic suggests another example of Whitehead's ontological timespace event, but from a sense of shifting symmetries. While the period of emergence suggests CoEs are unwieldly elements in the institutional environment, over time CoEs can act as more stable observatories. In some cases CoEs narratives captured the point at which a new 'institutional logic' of strategic research was felt:

> '… our Centre was funded before [research] impact really hit the scene, it hit the scene mid-way through and although I think we [were] tempted to adjust, I think there are some things that I have certainly shared with the program leaders as lessons learned' PL8.

However, CoEs may also act paradoxically to support institutional change by being a stable presence in the institutional flux. For example, narratives describe how CoEs can inherit 'institutional work', as people pass through the institution throughout the lifespan of the CoE. An interesting case is shown where experienced participants in the CoE Programme act, perhaps ironically, as a source of information - 'an authority' - during a period of institutional restructure:

> '...we take the lead on a lot of those meetings ... that's a challenge for us and for everyone - this whole restructuring is killing me' PL2.

Similarly, CoEs observe institutional responses to 'new' fields of science. Observers in these CoEs were also bemused by institutional investments and noted how their field approached amplification differently by dealing directly with the state, rather than the HEIs. This suggests an aspect of Weick's loose coupling where CoEs might act as "…independent sensing elements", which can act to dampen down faddish responses of tightly coupled systems (Weick, 1976, p.6). These observations align with work by Grodal and Granqvist who describe the discourse on nanoscience as a case where an amplification of a field of science can be "... stricken by fashion cycles … such as tulip mania" Grodal and Granqvist (2014, p.141). Grodal and Granqvist (2014), don't articulate the institutional logic which might be at play, but similarly note that 'odd' or counter-rational expectations within the institution are common in such a context.

Given the relative commonality of such odd encounters and paradoxical examples of the CoE-HEI interactions through the narratives, I discuss these in more detail in the following section to consider how these relate to an ontological view of the CoE.

6.3 Odd encounters and 'shifting ontologies'

" … Groucho Marx meets TS Eliot coming up the gangplank of a glass-bottom boat in Jamaica; Marx wants to discuss King Lear; Eliot wants to discuss Animal Crackers, and one excruciating dinner together is all they will ever see of each other."

(Eyre, 2011 on Craig Brown's One on One).

The 'inexplicable' encounters described in a number of CoE narratives closely resemble emergence in complex systems. This is neatly defined by Johnson as "... [a challenge in] predicting the complex temporal flows in interaction in response to rapidly changing properties of both systems and environment" (Johnson, 2006, p. 1475). Although transient, such encounters are clearly memorable and form important stories of the institutional life of the CoE.

These findings provide insight into the different spatial and temporal worlds of the CoE in relation to the institution, again in ways which support Whitehead's ontological view, and relate to Bourdieu's concepts of unequal exchange and expectations of mutual recognition (Bourdieu, 1986). Giddens (1984) similarly considers Goffman's encounters as spacetime events as important aspects of social structuration. Of importance firstly are futile encounters with the institution itself - the unsatisfying experience of information foraging. Here the sense is that Stafford Beer's autopoietic 'iron maiden' is still in residence. However, the concept that research is trapped within this institutional constraint is not clearly evident in relation to the CoE study.

Unlike the more traditional studies of organisational populations and life stage events - 'births, deaths and marriages' (Carroll and Hannan,1989; Hannan and Freeman, 1993; DiMaggio and Powell, 1983; Oehme and Bort, 2016), transient encounters may be important in studies of complex systems. Mohr and White (2008) would mark these out as the sort of stories we should be looking out for, as would Jain (2017). Mohr and White note this as "… flowing movement from one network situation into another and these situations are themselves phenomenological sites" (Mohr and White, 2008, p. 489). As the daisy chain effect in Brown's stories reveal - encounters such as these also form part of complex dynamics.

Latour proposes that in the case of understanding similar complexities in the social construction of science we also need to accept the "... shifting ontologies" of science (Latour, 2005, p.119). I re-interpret Latour's 'shifting ontologies' in relation to two aspects of the CoEs. Firstly, as emergent forms within the institutional environment and secondly through

the view of self-organisation of science as complex systems. In the section below, I consider how the CoE relates to five other studies to consider the potential to apply a view of shifting ontologies to network-like organisations.

6.3.1 Symbiotes, hybrids or proto institutions? Other network-like forms of organisation

Other studies of close equivalence to the CoE study offer differing views of network-like forms in an institutional environment (Lawrence et al, 2002; Ali, 2016; Oehme and Bort, 2015; Rigg and Mahoney 2013). Ali (2016) finds potential for symbiosis, Lawrence et al (2002) demonstrate potential for co-evolutionary effects, while Rigg and Mahoney (2013) demonstrate a case where the experiment of informality can fail in the institutional environment.

However, all describe forms of information exchange of relevance to network-like organisations. Another commonality of relevance to the CoE study, is the apparent 'role' of the network-like organisation as a type of intermediary form – for example as a conduit through the institutional environment.

In the case of the CoE narratives, some transdisciplinary CoEs indicated a challenge to establish or retain a cohesive form, which the modelling by Dodd et al (2003) suggest relates to information exchange potential. Woelert and Millar (2013, p.763) also note this 'paradox' of embeddedness and interdisciplinarity in sciences. They suggest structural issues in Australia's expectations for interdisciplinarity and lack of fit in the established fields of science system impact interdisciplinary. As Wagner commented when interviewed about national programmes, including Australia's CoE Programme, "...a distinction should be made between the kind of collaborative activity organized by scientists themselves — *where the research determines the organizational structure of the teams* — and the government-driven collaborations that have different objectives" (Nature Index, 2015, S82).

I explore this attribute of information flow in more detail below both in relation to earlier studies and by looking at the specific roles of the CoE Leads and how the conduit of information acts as the primary 'current' of the CoE.

6.4   The nurtured network – continuing Henry Oldenburg's legacy

The 'research profession' may be seen as an emerging group in the service of science. However, their role within what we see today as a globalised 'research ecosystem' aligns readily with that of Henry Oldenberg as instigator of the Royal Society. Oldenberg too was recognised as an exchanger and translator of global science information, a scholarly protagonist, an effective negotiator with the state, an "... encourager of younger natural philosophers" and "a born administrator" (Hall and Hall, 1965, np). These attributes could readily be applied to describe the modern Research Professional.

Although 'the researcher' has been given a level of precedence in studies, there is a growing interest in the 'ecosystem' aspect of institutional research. van der Cingel defines the 'plexus', the "wicker work" of science as "…interconnected or interdependent agents, organizations, and things" van der Cingel (2018, p.46). However, the CoE also has a level of energy and activity which is difficult to capture through this typification of objects. Latour's focus on the sociology of science highlights a dynamic view of an actor-network, "...the … actor-network is not the source of an action but the moving target of a vast array of entities swarming toward it" (Latour, 2005, p.46). This statement resonates with the self-described life of the CoE Leads.

Rather than finding an agnostic, unidimensional network of nodes and interconnections, the CoE narratives often described a 'nurturing network.' This is interesting as the (Weberian) 'institutionalised life' is typically seen as the one in which we are trapped because of the comfort it affords. A nurturing network could be described as one where information flow *within* the CoE was high, to the point that the CoE became a conduit to other institutions and had potential to 'infect' the institution, in ways similarly noted by Lawrence et al (2002) in their study of NGOs. However, unlike Ali's view of symbiosis between informal organisations and the institutional organisation of Defence (Ali, 2016), there was no clear evidence of any interorganisational CoE-HEI symbiosis.

Reading narratives from a network science perspective also highlights two areas of focus in relation to CoEs acting as 'true' networks in terms of their information capacity and network 'authority.' Firstly, CoE Leads can be seen to act as 'information hubs' to enact both the community and to generate a sense of gestalt in those engaged in the CoE. Secondly, that they can actively disrupt norms of science and organisational practice by rechannelling information processes. Two comments provide a summary of this, firstly in acting as a network 'authority':

'…So, I'm always trying to listen out and think 'oh yes this person, this student here should really speak to this CI here' RL17.

And secondly as supporting the culture necessary for the CoE to achieve a sense of the gestalt:

'… if you like you're the head of the family and - you've got several hundred people in here when you add in everyone down to PhD students and Honours students and you want everyone to feel 'I'm part of something' and 'people care about me and value me.' RL17.

Of relevance to considering the 'nurtured network' is the note by Lovink and Rossiter (2018, p.8) that, "…without continuous network maintenance, it falls apart." As one participant described the CoE '... it's in ... simultaneous states of creation, establishment and preparation for dis-establishment.' One of the challenges with network models – even those tested in relation to mass datasets of artefacts of science publications – is that these nodes appear inert and disconnected from the social construction of science. This offers another reason, as noted by Watts (2004) and detailed by Latour (2005) that there is a need to 'reassemble the social' in relation to network studies.

The unidimensional view of the science network through the lens of bibliometrics has been noted to be a problematic institutional device. As Borgman notes from her interviews with astronomers, "… constructing an astronomy paper is like building a house" (Borgman, 2015, p.90). When institutional research value is aggregated as researcher-institution-country pairings through bibliometrics data, this over-emphasises reputational values in global research (Aksnes, Schneider and Gunnarsson, 2011). Similary, over-reliance on bibliometrics as a 'metric for everything', from informing national science evaluation (Cronin and Sugimoto, 2013, 2014), to benchmarking national HE systems via university rankings (Harvey, 2007), has come under increasing scrutiny. Even publishers as promulgators of metrics are seeking a deeper understanding of the nature and culture of research production (Adams et al, 2019), particularly in relation to key systemic issues such as institutionalised gender inequity in (predominantly western) science (de Kleijn et al, 2020).

The challenge of maintaining 'the house' of science is no small effort and goes well beyond the named authors and list of citations. Even in the integrative review conducted for this research, appearances of prominent scholars, such as Harrison White, were often in the margins of papers rather than in the citations as an indication of their parallel 'invisible', network-making role.

Mabey and Zhou's study of CERN notes that despite institutionalisation, science networks within the system resist this effect to retain a low level of hierarchy. The CoE narratives describe cultural settings which may moderate this jump down effect from 'high orientation' of CERN to 'narrow science networks' at the project level in the ways proposed as problematic by Mabey and Zhao (2017). For example:

> '...it's very easy for a student to just arrive here and think 'thanks very much, I'm going to go to the lab and just leave me alone', but they're not allowed to do that, they have to engage in the Centre right? So ... once a month we have an 'all of Centre' meeting' RL4.

Similarly, while Mabey and Zhou find that addressing diversity in such an environment as the CERN-ATLAS case requires intervention, the CoEs demonstrate an ability to reset cultural norms to enable this change autonomously.

This nurtured view contrasts with some views of research collaboration growing via game theory-like action, observed as "… dynamics created by the self-interests of individual scientists, rather than to other structural, institutional or policy-related factors" by Wagner and Leydesdorff (2005, p.1616). Similarly, the view of the 'Centre Director' as corporate style managers who direct goal oriented 'team science' in institutional Research Centres (Boardman and Ponomariov, 2012), is not typically recognised in the CoEs. Most Research Leads didn't see the use of the term 'team' as appropriate. 'Groups', 'one woman and one man bands', 'members', were the alternative views of the collectives within the CoEs.

However, Wagner later notes a more Latourian view of the complex social construction of science, noting, that the 'actors' she found in global science were neither "cut-throat competitors", nor had they been somehow "coerced for social good" (Wagner, 2019, p.xiv). Rather than gaming for self-interest, formation of the CI group which established the CoE appeared to approximate Ostrom's alternate mode of collective governance, that "... if a small core group of users identify each other, they can begin a process of cooperation without having to devise a full-blown organization with all of the rules that they might eventually need to sustain cooperation over time" (Ostrom, 2000, p.149).

Another aspect of the nurtured network, given the lifespan of the CoE, relates to the Professional Lead role and the potential to establish a co-lead partnership. Given the relatively short life of the CoE, the potential for the core CIs and the Professional group to transition to a new 'small world' - similarly, not too connected, not too distant - to enact the next layer of the CoE could be critical to its cohesive establishment. Getting the 'right' Professional Lead was described in a number of cases as key to the success of the CoE.

Berman and Pitman (2010) note that postdoctoral professionals in research facing roles leveraged their information skills, rather than their 'knowledge' per se, in ways which resonated with Professional Leads in the CoEs and those engaged in the INORMS Focus Group; "…I get requests for information which leads to information-sharing, networking and other opportunities for collaboration" (Berman and Pitman, 2010, p. 161). As also noted in the Focus Group, interactions were predominantly directed to supporting research roles for information, training or orientation to the institution. This view of the role of the Professional Lead in a number of CoEs differs from studies where a more traditional view prevails, ie that there are efficiencies to be found through division of labour "... a clear distinction between director and administrator helps to remove role strain within the institution" (Philbin et al, 2014, p.2570). While there were cases in the CoE narratives where the two roles were more traditionally distinct, it appears CoEs become less impacted by such role strain related to the institution over time.

Bruce Macfarlane sets out the increasing overlays between researchers and ancillary institutional roles as an example of 'morphing of academic practice' and the rise of the 'para-academic.' In particular Macfarlane notes the traditional multidextrous teaching and nurturing scholar has been supplanted - perhaps complemented - by a range of professional services within institutions of mass education (Macfarlane, 2011). Conversely in this case, academically trained people are readily transitioning into professional roles.

In looking at the unique case in the CoE where we can see Research Lead and the Professional Lead as a 'duo', we can note similarities with the binary or co-leader role identified in Girvan and Newman's analysis of the interactions of Lusseau's dolphin study (Girvan and Newman, 2003; Lusseau and Newman, 2004), where information exchange is shared across two lead roles. This suggests that stable community structured networks could be enacted through ecological attributes of role diversity and synergy which allows effective information sharing. In this way the CoE as a nurtured network potentially takes on network attributes which makes it distinct to the 'autopoietic' institution.

The CoE as a multilayered network potentially also achieves a level of open synergy, rather than closed recursivity, through creation of its own environment:

'…I think of the Centre as more like a brain - than a pyramid … there's just lots of synaptic connections and a good brain is constantly growing new ones and *the Centre* is providing - an environment for that to happen in' RL17.

In such complex networks as the research ecosystem, the counting of publications and even the coauthorship outcomes of the network alone, provides us with the top half of the story - the wood produced, but not the ecology underpinning the forest. The synergistic

networks of the CoE Leads appear to be constantly at work, microglia or mycorrhizae-like, to pass information and reassemble resources to enable the knowledge work within the CoE to progress in ways that resemble a nurtured ecological network.

However, within the reality of the institutional environment, Centre Lead narratives also emphasise a direct effort to retain a connection via the Deputy Vice-Chancellor–Research and/ or the Dean which aligns with their closest faculty. This aligns with other studies that find Research Directors of Research Centres typically seek to ensure their reporting line is to a senior figure in the institution (Philbin et al, 2014). In institutionalist terms this suggests the CoE Leads may aim to gain legitimacy for 'their CoE' by linking to institutional resources and a conduit to executive power. Alternatively, as Oehme and Bort suggest in their review of biotechnology firms there is potential to explore a more "… nuanced view of imitative behaviour", noting that proximity or centrality may also act to benefit the more informal organisation by enabling information gathering (Oehme and Bort, 2015, p.629).

6.5 Between the dialectic and uncertainty - adapting institutional theory to complex environments

Jain (2017) suggests that faced with the dialectic of theory and the uncertainty of complex environments, the best approach is to take Steinbeck's non-teleological view (after Steinbeck and Ricketts, 1958). This avoids looking at a situation too quickly and assigning any 'sense' of cause and effect. The non-teleological view allows for a 'flow of information' being presented which allows an acknowledgement of anomalies, relational and underlying patterns. Rather than putting these to one side, these then become the object of further observation (Jain, 2017). As one participant in the CoE study noted, taking Steinbeck's perspective;

> ' … You can't explain things in your own rockpool, you've got to expose the rockpool to the whole ocean and that's what we do, but our goal is to understand the local' RL6.

In this research I consider the dialectic in institutional theory which allows a close alignment with the sociological basis in network science. Mohr and White describe this circular effect, as seen in the debate in institutional theory, as "… each debate evolving among factions within research communities over theories ... in terms of the institution immanent in its social organization" Mohr and White (2008, p.492). In this way they suggest, similarly to Latour before them, that research communities play a role in the evolution of theory which is itself socially constructed. As Nicolini notes "...once we have accepted that the world is the result of incessant processes of social construction we have begun our task" (Nicolini, 2009, p. 1393).

In the section I discuss some of the relevant aspects of theoretical perspectives in relation to the CoE study, through other domains. This considers the ways network science offers a further dimensional view and concludes with how this approach contributes to an emerging field which has considered combining aspects of institutional theory with studies of networks, dynamics and complex systems.

6.5.1   Actor-node-event? Other tests of theory in empirical studies of networks

The view of the 'actor' in institutional theory has relevance for this research in terms of how we consider both the CoE and the HEI. As noted from the findings, a view of 'micro-events', rather than more tangible interactions, may be important in views of institutional inter-relationships. This was highlighted in the debate convened by The Editors of the Journal of Management Science in 2014. As noted earlier, Meyer and Höllerer, (2014) emphasised the importance of a focus on 'organising' by pluriform organisations, while Greenwood, Whetten and Hinings (2014) propose a refocus of institutional theory on the organisation as the 'actor'.

Papers of interest in the integrative review, which focussed on the actor/agent and the node, as well as the perspective of events were reviewed in more detail in relation to the CoE study. In making their case for a return to order in institutional theory, Greenwood et al (2014) also canvassed the literature, looking at 45 empirical studies conducted over three years (2010-2012 inclusive) which focussed on institutional processes. Their selection overlaps with a number of papers selected for the integrative review for this research and some similarities are evident. For example, while some value was noted in the predominance of studies on diffusion practices, adoption and change, Greenwood et al propose a rebalance for "… a deeper and programmatic concern for how organisations are designed and function in [dynamic] contexts" (Greenwood et al, 2014, p.1210).

Meyer and Höllerer were rather worn down by it all, writing "…we doubt that the intellectual staleness of institutional diffusion studies can be overcome with a remake of contingency studies starring institutional logics" (Meyer and Höllerer, 2014, p.1228). Despite their debate in 2014, Greenwood and Meyer had earlier shared in recognising the remarkable achievement of the publication of 'The Iron Cage Revisited' on its 25th Anniversary, concurring that "… DiMaggio and Powell explicitly linked institutional thought to ideas about networks" (Greenwood and Meyer, 2008, p.260). This affirmed potential to explore new studies which reconnected the network with institutional theory.

Of the papers in the integrative review, the reference to 'policy **actors**' by Persson (2018) is the most prominent and specific use of the term 'actor.' Persson's case study of reform of the European Research Council (ERC) in 2000 offers parallels to the formation and role of the Australian Research Council. Persson affirms the reform of the ERC as a "…bottom-up process in which representatives of agencies and organizations in the scientific community are active", while also noting a level of institutional power play (Persson, 2018, p.416). The active role of CoE Leads feeding back into ARC policy, provides a similar example of how the network-like community of science, perhaps through

its continuity, can potentially offset more institutionalist influences on the CoE Programme. In this way too the CoEs are seen as having 'embedded agency' in the science system and not in the HE system.

Conversely the use of the term '**node**', which could be considered the network science equivalent for 'actor' – in that a node serves as a point of interaction – is less frequently used. Henriksen and Seabrooke (2016) and Caspar and Murray (2005) make most prominent reference to 'nodes' and are the only authors who refer to work from the field of network science. In particular, Henriksen and Seabrook's focus on transnational organising refer to nodes as both organisations and professionals in a sustainability certification network. They consider Watts and Strogatz 'small world network' (after Watts, 1999) and test entropy as an information value in a complex network.

Pflitsch and Radinger-Peer take the view of the universities as potential transboundary 'actors' in sustainability. They track '**events**' over a twenty-year period and place their focus on 'events' and 'actors' in shaping the "…boundary-spanning activities of the university" (Pflitsch and Radinger-Peer, 2018, p.917). Their detailed findings, that one institution responds to sustainability while the other does not, reaffirms the challenge of direct studies of the institution.

As noted in the CoE case, less formal, asymmetric 'relational spacetime events' in the HEI environment may be of importance in understanding the emergence of other organisations. In Whitehead's example of the car crashing into Cleopatra's Needle, we gain a clear view from understanding what constitutes a 'notable event' for the CoE might be imperceptible to the 'institution' in its durable and symbolic narrative (after McHenry, 1997, p.8)

This challenge with the application of institutional theory, particularly in the selection of a relevant sociological perspective, is discussed in more detail below.

6.5.2   The trouble with the theory of everything

As these empirical studies demonstrate, references to institutional theory struggle to neatly resolve the dialectic when looking at network-like organisations in the institutional environment. This could account for some of the challenges in 'moving institutional theory forward', in particular to explore the value of theory in complex systems studies.

Similar to findings from this research, studies which apply an institutional theory lens to collective action in institutional environments, identify apparent dualisms and paradoxical cases. Persson (2018) finds evidence of the work of both the science collective and the institutionalists in the case of ERC reform, depending on the perspective taken. Pflitsch and Radinger-Peer (2018) note that even a careful exposé of events across two similar HEIs can't explain very different institutional responses to the emergence of new regional organisations promoting sustainability. Henriksen and Seabrooke (2016) acknowledge institutional theory has relevance in the ambiguous environment of transnational networks of professionals working in sustainability certification, but are not able to say exactly how theory can be extended in this case.

One criticism of readily applying neo-institutionalism was that DiMaggio and Powell's approach was too eclectic. As Scott noted, institutional theory runs the risk of trying to be the "theory of everything" (Scott, citing Palmer et al, 2014, p.139). A notable controversy in efforts to extend institutional theory to complex systems was Carroll and Hannan's effort to link institutional legitimacy with population ecology to account for organisational complexity (Carroll and Hannan (1989). This was seen as a step too far by other institutional theorists (see Zucker, 1987; Baum and Powell, 1995).

However, the reverse case now seems to be more common. That is, that neo-institutionalism is being stretched to 'fit' managerial complexity (Davis and Marquis, 2005). Tolbert and Zucker (1996) also noted a concern that institutional theory itself was constrained by a type of institutionalisation (sic), or rule setting. They foresaw that theoretical explorations needed to be applied more widely. Psycho-cultural aspects of institutional theory introduced by Weick; sense-making, cognition and loose coupling, which were later incorporated in Scott's institutional theory framework (Scott, 2008, 2014), were also recognised as being 'passed over' in preference for "... a new managerialism" in the millennial period (Meyer, 2002, p.612).

One persistent tension is that while a number of those reviewing institutional theory, such as Davis and Marquis (2005), note value in reaching back to 'reclaim' original concepts overlooked in 'new' institutional theory, others recommended returning to an

emphasis by Selznick on the pragmatic views of power, agency and purpose promoted by Hinings and Greenwood (2015) or the "… broader Weberian understanding of rationality as institutionally contingent" (Lounsbury cited by Styhre, 2011, p. 377).

This dialectic split between (typically Weberian) institutionalists on one side and neo-institutionalists on the other has gone through periods of waxing and waning. As Vallett and Ventresca note "... for every institutionalist there has been an interactionist" (Vallett and Ventresca, 2006, p.213). However, even economic (rational) institutionalists Knight and North (1997), who continued to assert the atomistic view of institutional formation, took on the possibility of broader ideas. In their review of Hutchin's work on 'Cognition in the Wild' (Hutchins, 1996) they acknowledge the less tangible aspects of 'social cognition' in terms of "... the enculturated concepts of beliefs and contexts in forming institutional patterns" (Knight and North, 1997, p.222).

There are signs of other domains engaging with neo-institutional theory which signal a value in the application of theory to other contexts. Vargo and Lusch, whose interest focuses on service dominant (SD) logic in organisations, propose neo-institutional theory offers potential to consider ecosystem views, as "…the dynamic structures of markets" (Vargo and Lusch, 2017, p.48). Although they note work by Scott, they further offer that "…SD logic might provide a theoretical framework that can contribute to this reconciliation and to the general advancement of institutional theory" (Vargo and Lusch, 2017, p.54).

As noted earlier, there is also interest to engage with complex systems and sustainability through the lens of institutional theory. Sjöstedt (2019) – working in the field of sustainability governance – suggests that studies of complex systems have potential to extend institutional theory by considering emerging institutional arrangements. An example of this, by Genus (2014), notes the role of neo-institutional theory in informing sustainability governance – notably through the shift from "… the rationalistic assumptions [of economic institutionalists] attributed to "homo economicus" and considering an evolutionary perspective" (Genus, 2014, p.284). Of most value here is the connection with Ostrom's view of governance which ties structuration effects in collective action to neo-institutional theory.

6.5.3 The Granovetter-Watts bridge: reconvening the social with network science

The integrative review also brings to the fore the two physicists turned sociologists, Harrison White and Duncan Watts, who offer a connected lineage for institutional scholars to draw on in connecting to network science. White through his own legacy of work in sociometrics and via that of his students Granovetter and Powell. He is also attributed with the source of DiMaggio and Powell's 'new' institutional thinking (Greenwood and Meyer, 2008). Watts also deserves recognition for his Latourian efforts to 'reassemble the social' in network science (Watts, 2004).

Granovetter's foundational leap to link mathematical studies of the network to social psychology is now recognised as the 'bridge' between social theory and the work of network science (Granovetter, 1973; Watts, 2004). In scaling up sociometric studies, Granovetter also considered the wider aspects of social structure, paving the way for networks to be studied at the organisational level. Greenwood and Meyer (2008) also emphasise these connections, noting "… both [DiMaggio and Powell] were involved in social network research and were strongly influenced by the work of Harrison White."

However, a shared vocabulary is considered a potential limitation to reconciling these apparently divergent enterprises. In reflecting on the 'actor' in complex systems, Watts (2004) notes the consideration of actor in the sociological sense: "… large changes in dynamical behaviour could be driven by even subtle modifications to the network structure - modifications that may be imperceptible to actors with only local knowledge of the network" (Watts, 2004 p. 246). This statement then aligns his discussions in network science with the view of the level of cognition in the collective made by DiMaggio and Powell (1983) and the concepts of Giddens' structuration theory.

6.5.4 Combining theories to gain new views of the network

Although this research demonstrates foundational links in sociology between network science and neo-institutional theory – there remain two questions. Firstly, whether these two fields can be applied in concert in support of Meyer and Höllerer's proposition for studies which adopt a complex design, and secondly, whether their application moves us toward resolving any ontological question about network-like organisations?

Network models based on organisational archetypes, such as those by Dodds et al (2003) provide a link to established theoretical approaches. Both institutional theory and

network science have also been engaged in understanding the next level of complexity - in recognising paradoxical and Steinbeck's 'hard to place' observations. I use the example of paradox below as a common thread in combining theories and recent studies in network science to research complex organisational environments. I then consider how this research contributes to 'locating' institution theory within a framework which supports complex designs.

6.5.4.1 Paradoxical insights into the institution and the network

The paradox perspective has been defined as "... tensions in a system [which] may be viewed as persistent, opposing but interconnected poles, which allows for dualisms, rather than dualities (Papachroni, Paroutis and Heracleous, 2016, p. 6). Granovetter highlights the value of paradox considerations in understanding social networks as "... a welcome antidote for theories which explain things all too neatly" (Granovetter, 1973, p. 1378). In bringing an approach from exploring the paradoxical case of weak ties, which link the micro and macro levels in a network and lead to integration, while strong ties, which create "local cohesion, (but) lead to overall fragmentation", Granovetter establishes one of the central tenets to link organisational views of the network and the institution (Granovetter, 1973, p. 1378).

Paradoxical findings through application of institutional theory are evident, and, in some cases the focus, of the other studies. Tracey and Creed (2017) advocate a value for institutional theory to tackle paradoxical cases. Like Meyer and Höllerer (2014) and Davis and Marquis (2005), they propose that institutional theory needs to be stretched, rather than "... retreating further … into a narrow range of managerial challenges and dilemmas" (Tracey and Creed, 2017, p.169). Rather than seeing paradox as a set of 'competing institutional logics' which can be 'managed', Tracey and Creed propose a view of emotional dynamics of institutional paradoxes. Tracey and Creed also extend the challenge to scholars to consider the complex 'big' institutions of class, race and gender perpetuated in social organising.

Work by Voronov highlights that institutional theory can be applied to 'new' emotions "... [that] are not consistent with the dominant logic, which tend to be constituted as 'emotions' and cast in opposition or in conflict with whatever is "rational"" (Voronov, 2014, p.187). The potential for the CoE to both experience, but also offset, institutional effects could be of value for further exploration. In particular the CoE demonstrates adequate distance from the dominant logic within the HEI to shape new norms and generate alternative policies as a protagonist for change.

However, the use of paradox theory alongside institutional theory and considerations of findings in network science may have wider potentials. Network science naturally engages with paradox as probability which aligns closely with the types of dualisms prevalent in institutional studies. As noted earlier in the case of Borel's Paradox, which I applied to consider the narratives of 'non-events' and expectations inherent in the institutional environment, the probability of events can form a useful indication of emergence.

Recent studies in the field of network science have focussed on similar classical paradoxes. These include the Friendship Paradox (your friends have more friends than you do) and Braess Paradox, (adding an additional link between nodes A and B reduces the effective connection between A and B). This has some relevance to considering how network-like organisations might 'behave'. For example, models of Braess Paradox, which consider 'the price of anarchy' vs 'the price of stability', resonate with the narratives relating to the CoEs' Chief Investigators! Mak and Rapaport's experimental findings of decision-making in routing choices through a network relate to game theory (Mak and Rapaport, 2013), also closely relate to Ostrom's views of open collective organising and the evolution of norms. For example, in network terms, Mak and Rapaport find that "...equilibrium strategies are stable, as no decision maker may benefit from unilateral deviation" (Mak and Rapaport, 2013, p.150.). Their findings resonate with Ostrom's proposition that "... if a group of users can determine its own membership … the group has made an important first step toward the development of greater trust and reciprocity" (Ostrom, 2000, p.149).

Further data techniques also highlight network scientists' interest in 'richer data' and cross over into sociological questions. For example, Newman & Clauset (2016) recognise the potential for more complex metadata labels to be applied to detect network attributes based on the Friendship Paradox.

This suggests further revelations in network science could be aligned by bringing a theoretical lens to play, and some potential to develop this approach is considered in more detail below.

6.5.4.2 Resolving tensions in extending institutional theory to complex designs

While there have been efforts to reconcile dualisms in institutional theory (see Greenwood and Hinings, 1993), these reflective views of the use and application of institutional theory point to the need to continue to take on new perspectives in approaches which can accept dualisms in complex contexts. More recent studies are also applying mixed

methods through exploratory approaches to tease out and visualise the layers and boundaries of relationships that make up the institution and the network.

My research adopts an approach of 'switching lenses' (after Nicolini, 2009) and considers potential for complementary lenses to explore complexity (Smith and Tracey, 2016). Smith and Tracey consider combining institutional complexity and paradox theory and note that, despite divergence, "...institutional theory has potential to support paradox theorists' understanding of tension salience … while paradox theorists point to leadership and individual sensemaking" (Smith and Tracey, 2016, p.460). Nicolini notes that different traditions can be "...mobilised together" where they "...subscribe to some key common tenets" (Nicolini, 2009, p.1394).

Similarly, work by Modell, Vinari and Lucca (2018) emphasises why the double lens approach needs to have congruence with the object in focus. They explore the role of agency in their review of applications of institutional theory with Latour's Actor Network Theory (ANT) to studies of innovation. They consider studies with an emphasis on individual entrepreneurism to be problematic where they create "... a lack of sensitivity to the historical contingency of *social* embeddedness…" intended by Latour's theory (Modell et al, 2018, p.66). Alcadipani and Hassard note similar challenges for ANT being applied in Critical Management Studies (CMS), with some authors suggesting ANT and CMS are "... analytical opponents" (Alcadipani and Hassard, 2010, 420). This type of commentary is often plagued with the 'rational human agent' argument, which creates much of the dialectic in institutional theory - to the extent that we are left with handling "... ontological politics" (Alcadipani and Hassard, 2010, p. 421).

A review by Martin (2003), which traces connections in field theory by Lewin, notes the link to the organisational field in 'new' institutional theory by DiMaggio and Powell in concert with Bourdieu's view of social topology. Martin expresses a similar anxiety to Davis and Marquis (2005) in that, despite an evidently changing world, "... yet all is quiet on the theoretical front" (Martin, 2003, p.2). Martin notes that DiMaggio and Powell (1983) effectively "... brought a state of completion" to institutional theory by aligning the concept of the organisational field with that of Bourdieu's view of relational ambiguity (Martin, 2003, p.27). In this way Martin notes how neo-institutional theory allows for the complex arrangement of self-organisation across all the organisational forms that constitute 'the field.'

At a more pragmatic level Akcam, Guney and Cresswell (2019) have looked at how qualitative studies could bridge theory and systemic studies. In bridging grounded theory and Forrester's systems dynamics, Akcam et al (2019) have similarly used two lenses at sequential and iterative levels of analysis to address qualitative data. They note this as a means of addressing the "...qualitative analysis thicket" (Ackam et al, 2019, p.3).
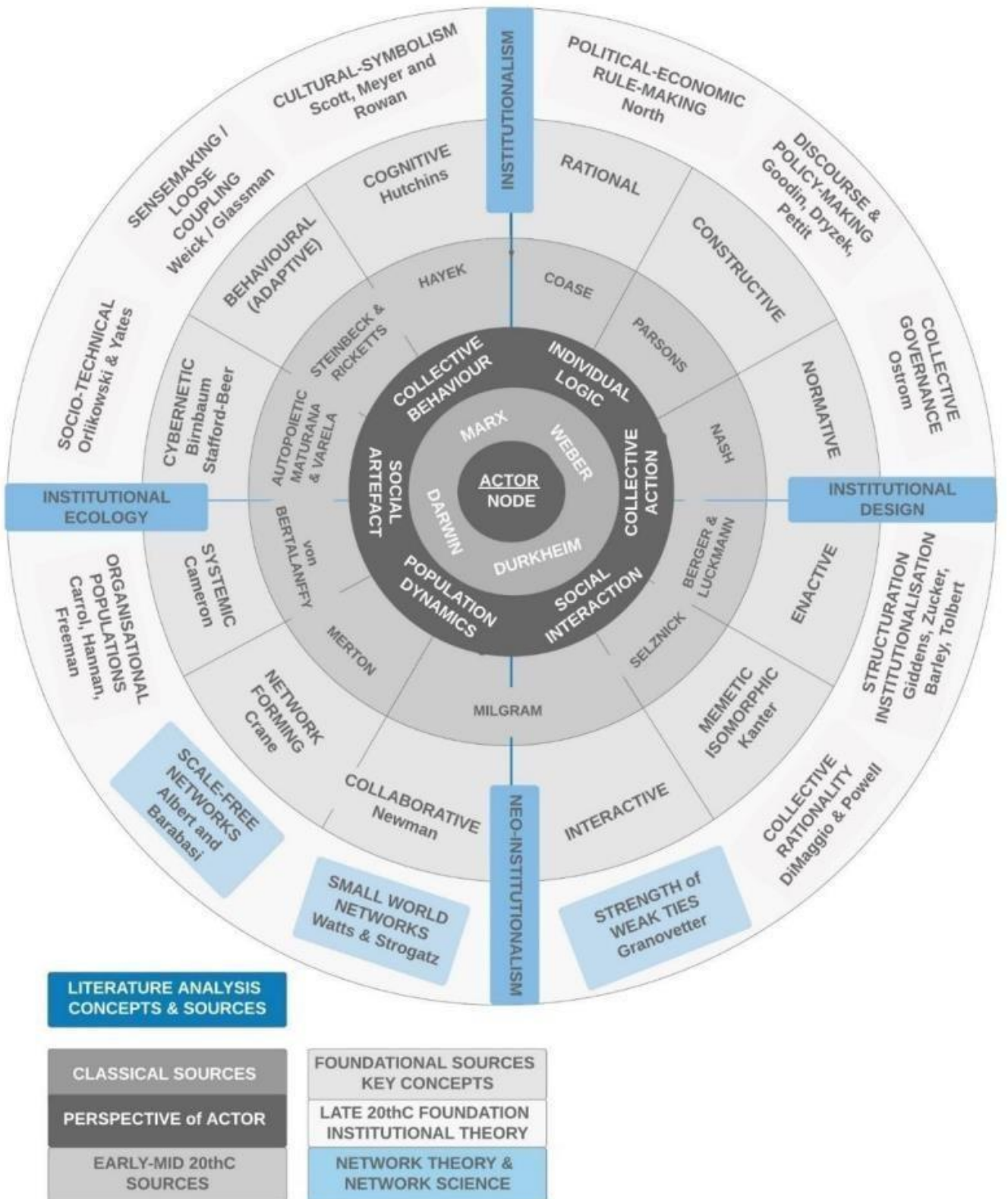
In the case of the CoE study, rather than turning institutional theory as 'isomorphism' and networks as 'centrality' (for example) into quanta - I 'converted' much of the network science models to their descriptive form in order to retain a qualitative approach. The second level analysis as network narratives using network models generated in other domains re-examined models in relation to institutional theory aligns with an approach taken by Akcam et al to minimise bias inherent in "... the 'rich' use of generic structures and archetypes" (Akcam et al, 2019, p.7).

The ultimate product of this review and analysis is an open architecture framework for institutional theory which links to network science as shown in Figure 6.1. The open architecture framework emphasises the shared underpinning with network science in sociological studies and brings forward a translation of network terms within institutional theory. The framework builds on earlier work by Scott (2005; 2008) and contributes to further steps in the process of 'remaking the network visible' in institutional theory, but does this in reference to findings from the empirical case. Finally, the analysis 'tests' this open framework to provide a synthesis of shared narratives and experiences of CoEs.

This open architecture approach aligns with recent work by Town, Donovan and Beach (2020) who consider a 'quantum view of the gestalt' in looking at organising and noting the individual's experience in terms of emotion. Given the findings in the CoE case that ambiguity, inexplicable encounters and non-encounters in the institutional environment affects how the participants saw themselves and the institution - this may have value for further exploration. In particular, in noting how such apparently random events may then become a discourse in resolving individual 'sensemaking' against more consistent "salient" or "sensible" interactions, resonates with similar observations by Town et al (2020, p.16).

Figure 6.1   An Open Architecture Framework for studies of the institution and the network

INSTITUTIONALISM

CULTURAL-SYMBOLISM
Scott, Meyer and Rowan

POLITICAL-ECONOMIC
RULE-MAKING
North

SENSEMAKING /
LOOSE
COUPLING
Weick / Glassman

DISCOURSE &
POLICY-MAKING
Goodin, Dryzek,
Pettit

COGNITIVE
Hutchins

RATIONAL

BEHAVIOURAL
(ADAPTIVE)

CONSTRUCTIVE

SOCIO-TECHNICAL
Orlikowski & Yates

HAYEK

COASE

COLLECTIVE
GOVERNANCE
Ostrom

STEINBECK &
RICKETTS

PARSONS

NORMATIVE

CYBERNETIC
Birnbaum
Stafford-Beer

COLLECTIVE
BEHAVIOUR

INDIVIDUAL
LOGIC

AUTOPOIETIC
MATURANA
& VARELA

SOCIAL
ARTEFACT

MARX   WEBER

NASH

INSTITUTIONAL
ECOLOGY

von
BERTALANFFY

DARWIN

ACTOR
NODE

COLLECTIVE
ACTION

INSTITUTIONAL
DESIGN

DURKHEIM

BERGER &
LUCKMANN

ENACTIVE

SYSTEMIC
Cameron

POPULATION
DYNAMICS

SOCIAL
INTERACTION

STRUCTURATION
INSTITUTIONALISATION
Giddens, Zucker,
Barley, Tolbert

ORGANISATIONAL
POPULATIONS
Carrol, Hannan,
Freeman

MERTON

SELZNICK

NETWORK
FORMING
Crane

MEMETIC
ISOMORPHIC
Kanter

MILGRAM

SCALE-FREE
NETWORKS
Albert and
Barabasi

COLLABORATIVE
Newman

INTERACTIVE

COLLECTIVE
RATIONALITY
DiMaggio & Powell

SMALL WORLD
NETWORKS
Watts & Strogatz

NEO-INSTITUTIONALISM

STRENGTH of
WEAK TIES
Granovetter

**LITERATURE ANALYSIS
CONCEPTS & SOURCES**

CLASSICAL SOURCES

FOUNDATIONAL SOURCES
KEY CONCEPTS

PERSPECTIVE of ACTOR

LATE 20thC FOUNDATION
INSTITUTIONAL THEORY

EARLY-MID 20thC
SOURCES

NETWORK THEORY &
NETWORK SCIENCE

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6.6 "Schrödinger's next cat": new meetings in the sciences of organisation

The integrative review conducted for this research aimed to gain an understanding of the potential for two bodies of literature; institutional theory and network science, to be drawn together to support studies of complex systems of human organisation. Reflections and reviews, including discourse on whether theories informed in 20th Century contexts continue to offer value in the 21st Century, were examined to consider whether the addition of an institutional theory lens offered a bridge for complex systems studies. The research highlights two challenges; firstly, the loss of engagement to 'follow the network' inherent in neo-institutional theory, secondly, the inevitable drift in research culture and language such a bifurcation has had on bridging institutional and network perspectives. However, the scale and scope of challenges in approaching complex systems studies is an ongoing conversation in both fields of interest.

The starting point for this analysis was a proposition that "... the strength of institutional theory was that it sought to make sense of organisations as part of complex social systems" (The Editors, 2014, p.1204). In response to work by Thornton et al, this research also seeks to consider whether the concepts of networks and dynamics in 'new' institutional theory were "... vacuous without knowing on which institutional orders actors in the field draw" (Thornton et al, 2012, p.32). Their view was that this could be resolved via a logics approach, which would return focus to 'the organisation' and reinstate the role of strategic action and cognition.

This tension among institutional theorists is matched by network science's search for new phenomena. While physicists aren't fazed by dualities, Mark Newman acknowledges that network science is yet to find a paradigm changing theorem - their "Schrödinger's cat", noting "... we've discovered a bunch of interesting things, we have a bunch of tools, but who is to say they are the right ones" (Oxford Internet Institute, 2016). Meyer and Höllerer also point to this stimulating but unsettling period in institutional and organisational studies which has returned a "...vast and increasingly confusing mound of research on divergent issues and phenomena" (Meyer and Höllerer, 2014, p. 1227).

For organisational scholars and network scientists alike, there is a sense that the structures and architectures of social organisation are well studied, but network function, enigmatic qualities of space, time and further paradoxical findings in complex systems suggest further challenges ahead. The evidential rise of the 21st Century tech giants alone suggests a sociotechnical phenomenology predicted in DiMaggio and Powell's citation of Granovetter (1978) that "…for any relevant dimension of structures in an organizational field

there will be a threshold level, or a tipping point, beyond which "… adoption of the dominant form will proceed with increasing speed" (DiMaggio and Powell, 1983, p.156). Powell later looked to reconcile institutional theory and network theory, but faced challenges with reconciling logics with points of complexity, noting "… logics render networks and organizational structures sensible in particular fields, but many, if not most, activities are amenable to multiple logics (Owen-Smith and Powell, 2008, p.602).

Barabási, whose work with Réka Albert modelled such scale-free phenomena in science networks, later reflected on an agenda for a theory of complex systems noting a need to consider "... the next frontier of the system's typology", by first "... under-stand[ing] the dynamics of the processes that take place on networks" Barabási, 2009, p.413). This focus on dynamics signals an opportunity for concepts to link with 'new' institutional theory. But here too there is a challenge of scope, "...the problem is that we have almost as many dynamical phenomena as there are complex systems" (Barabási, 2009, p. 413).

Research culture is also highlighted as another potential barrier to bridging the diverse fields with an interest in the sciences of organising and the organisation of science. As Bernie Hogan quips, "...sociologists worry about physicists colonising their field like Canadians worry about Americans colonising Canada, but the reverse not so much" (Oxford Internet Institute, 2016, np). A clear example is Phillip Bonacich's protestation of the ingress of physicists via network science, declaring that " ... all the early important theoretical and empirical work (in social network analysis) was done by sociologists or anthropologists" (Bonacich, 2008, p.426).

However, Latour's experience suggests natural scientists actually do mind when sociologists prod around in their field of practice. This story has some relevance in informing how complex systems of science organisation can be both effectively viewed and approached as an object of sociological research. In a detailed interview with Ava Kofman, Latour reflects on the shock of his colleagues in 1976 when he revealed black and white images of scientists at work, much as a zoologist would report on a study of a group of chimpanzees (Kofman, 2018). Despite the poor footing of inter-collegiate relationships between sociologists and possibly every other type of scientist, more recently Latour has been a protagonist for the communication of climate science. He relates an observation of a new "cosmology of science", where a scientist 'makes the network visible' as "... a seismic rhetorical shift: from ... appealing to transcendent, capital-T Truth to touting the *robust networks* through which truth is, and has always been, established" (Kofman, 2018, np).

Bonacich's field of mathematical sociology has also subsequently made progress to reconcile with new ideas in network science and co-recognition of these fields (Bienenstock

and Bonacich, 2021; Hexmoor, 2015). However, groups with a network interest from a complex systems perspective have tended to continue to look toward scholars in network science, rather than consider mathematical sociology (see Sayama, Cramer, Sheetz and Uzzo, 2017). While the integrative review found analytical studies applied a combination of institutional theory (often as isomorphism) with methods derived from mathematical sociology, notably via estimations of centrality and diffusion calculations, very few studies took a complex systems perspective. Notably, those who have explored this opportunity through institutional theory are also working in the figurative and literal 'green space' of collective governance in sustainability. This includes interesting work in community deployment of renewable technologies as a new 'common pool resource' (see Genus, 2016; Henriksen and Seabrook, 2016 and Sjöstedt, 2019).

In addressing challenges in broaching interdisciplinary approaches, Newman echoes Watt's call (Watts, 2004) for a clearer vocabulary to enable future studies which stretch beyond the current toolkit of network models. He notes the example of 'homophily' or 'the Matthew Effect' in social sciences and its translation as 'preferential attachment' in network science, to acknowledge there is more fundamental work to do - "... people don't understand each other's languages [in order to] combine ideas from other fields" (Oxford Internet Institute, 2016). Even within fields this can prove challenging as Crawford and Ostrom outline in their effort to corral an institutional grammar, noting "... analyzing complex institutional configurations will require new [grammatical] capabilities" (Crawford and Ostrom, 1995, p. 569).

Conclusion

At its heart this research provides insights into the 'institutional life' of the Australian Centres of Excellence (CoE). Conceptually the research design placed the CoE as a Janus object in the overlays of network-like organisations in both institutional and networked environments. A further overlay which considers complex systems provided the guiding model for this research. In this way the empirical research aimed to simultaneously capture 'data of observations and experiences' of the institutional and network environments. In turn the research adopted an exploratory approach to gain understandings of whether the CoE can act as an incursion in the institutional field. And if so – to what effect?

To understand these views, the research synthesised the findings from three studies. These were: an integrative review to support the theoretical approach to the research; an informative study of the research profession and thirdly the study of the ARC CoE Programme. Studies of similar National Research Centres were typically viewed at a point of establishment in time, often as an embedded 'unit' within the national research system. In contrast, the CoE Programme offered an opportunity to capture dynamic views across the lifespan of the CoEs. In this case the three cohorts of CoEs established in 2011, 2014 and 2017 were seen to be a population of emergent and transient forms in relation to the established nature of the HEI partners which also constituted the Programme.

New ripples in an institutional theory of organising

This research presents a new open architecture framework for the exploration of 'organising' within complex institutional environments. This is a presumptuous step, given the grounding Scott's framework holds in supporting applications of institutional theory (Scott, 2004, 2008). I trust the framework recognises Scott's encouragement to see institutional theory in terms of an 'open architecture.' The circular design was also prompted by Scott's view of the continuing 'ripples' of institutional theory (Scott's, 2014). By presenting the main informants of institutional theory in a circular framework I also aim to highlight relational studies within a wider frame of complex systems.

I introduce two new conceptual elements to complement Scott's original three pillars framework. Firstly, by 'splicing' the connections of network science into a schema of institutional theory. The framework allows this by linking the field of network science back to its sociological relationship. In particular this represents a relational link to neo-institutional theory. Secondly, based on the findings in the CoE study, the framework places a Janus object in the centre. In this way the object in focus can be considered an observer of the institutional environment or an actor within it. Alternatively, the object can be

considered a node or, as found in the case of the CoE, as a relational object, a spacetime event, which may present paradoxical findings.

The engagement with the literature considers how institutional theory can be moved forward in concert with network science in forming studies of complex forms of organising. As found throughout the research, institutional theory retains a high level of utility in exploring emerging forms in institutional environments. In particular, the concept of 'the field' and the inherent consideration of networks in neo-institutional theory, demonstrate further potential in studies of complex systems. However, the integrative study suggests that neo-institutional theory, while still widely sourced and applied in organisational studies, demonstrates a continued focus on 'isomorphism.' This continues to highlight the reduced consideration of the network aspects of neo-institutional theory, as noted by DiMaggio (1995) and in later reviews by Greenwood and Meyer (2008).

In the same studies, networks were also viewed through a relatively narrow lens. Measures, such as 'centrality' are a predominant factor of interest for multivariate analyses, particularly in analytical studies which also consider isomorphism. However, wider considerations of findings from more recent studies of network science are limited. A useful finding through the cluster analysis of the literature was the identification of subsets demonstrating a closer engagement with methods in mathematical sociology. This allowed a connection to be made between this established field of social network studies and the 'newcomers' to 'network science.'

The integrative literature review proved to be an important co-informant for the empirical studies. The methodology adopted of 'switching lenses', to gain institutional and network perspectives through each study (after Nicolini, 2009), drew on sources from the review. The integrative review also correlated sets of foundation and review articles in each field. Reading across the papers also established theoretical commonalities within the literature.

An ontology of the organising form

The research also explores an 'ontology of organising', which aligns with a complex systems view. As an exploratory study, the rich narratives from the CoE Programme contributors, provide new insights into the pluriform nature of the CoE cohorts and the pluripotential nature of individual CoEs. Interview data was explored first through the theory of institutional theory and then by 'walking through' narratives from using organisational

models developed in network science enabled formation of a set of 'typologies' of CoEs which could be subject to further study.

The concept of network narratives is derived from network pictures (Ramos and Ford, 2011). However, rather than considering dyadic connections, the narratives are developed in relation to network models proposed by Watts (2004). As demonstrated in the analysis these models allow consideration of multiscale effects in relation to the narratives and suggest a set of network typologies based on the narratives.

These 'network narratives' firstly affirm the multilayered nature of the CoE but importantly distinguish them as pluripotential forms. This suggests that CoEs form as pluriform types, as suggested by Meyer and Höllerer. Of particular interest is that these types are not necessarily related to a field of science or a particular institutional environment. Ontologically we can also view CoEs as network-like forms which act as highly effective information conduits or intermediary forms in relation to the institutional environment. This aligns with findings from similar explorations of informal organisations in highly institutional environments which suggests characteristics in common with other findings of network-like organisations by Ali (2016) and Lawrence et al (2002). In comparison with studies of large institutionalised research systems – such as CERN (Mabey and Zhao, 2017; Wagner, 2018), the CoEs as an organisational 'step down' or intermediary appear to function effectively to offset both the highly institutionalised parent environment and the 'stubbornly localised' science groups.

However, in the case of the CoE narratives, we see how this intermediary role is also enacted by the CoE Leads who 'activate' the 'stubbornly localise' groups. Ontologically, the comparison of the CoE with other 'organisations' in the literature generally affirmed what a CoE was not, rather than what it was. The ontological guide was developed for this research considered three prospective views: firstly, that the CoE had an ontological status as an embedded object in the national institutions of science; secondly, they could be view in a relational sense as spacetime events which allowed for the asymmetry and transience in relation to the HEI. Thirdly, as a form of 'organisation of science', the participants would determine the form of the CoE based on a particular practice or ontological commitment to their field of science.

In line with findings by Lawrence et al (2002), the CoEs similarly demonstrated potential to overcome an institutional threshold to influence policy settings. In my findings I consider the term 'percolation' based on the network science description to describe this effect in the case of the development of gender policy (after Newman, 2003). This aims to

distinguish this type of transmission from more passive diffusion where policy and practice is 'passed down or through' a dominant or hierarchical organisational form. This case demonstrates ways the CoE effectively 'infects' the institution. This substantive narrative across the findings is particularly significant in considering the potential for systemic and co-evolution effects of the CoE.

Observations of the institution

The potential for the CoE to both experience, but also offset, institutional effects could be of value for further exploration. In particular the CoE demonstrates adequate distance from the dominant logic within the HEI to shape new norms and create alternative policies as a protagonist for change.

Through this analytical approach we gain a view of the life of the CoE in the institutional environment. Firstly, based on the network narratives, we can describe the CoE as pluripotential and a pluriform type. However, based on more unexpected observations and experiences in the institutional environment we see the CoE as an emergent form in a complex system. In particular we can note narratives of initial ambiguity in relation to the spatial environment. This can be followed by an uncertainty phase in relation to information sourcing, but also in relation to non-events. The institution is found to be unresponsive. A type of co-existence is achieved as the CoE narratives describe coherence as the COE is viewed as a whole. From this point narratives move from self-organising to emergence over scale. In a number of cases the 'final' view of the CoE is not as an entity but as a Gestalt.

An understanding of these observations and experiences within the HEI environment also affirms the organising nature of the CoE. Counter to expectations, CoEs did not form inter-organisational ties with the HEI in the sense they would be an 'ecosystem' pairing (Autio and Thomas, 2014), nor do they act symbiotically with the HEI as noted in other cases of informal organisations and institutions (Ali, 2016). CoEs do not readily align with the typologies defined for more formalised research centres. Clearly, they are not 'quasifirms' (Etzkowitz, 2003). In a case of NGOs within an institutional environment, Lawrence et al (2002), apply the term 'proto-institutions.' However, as they qualify, this does not signify the organising form institutionalises, but rather, having organised, the new grouping has the potential to produce policy of relevance to the institution. This demonstrates a shifting ontology (after Latour, 2005) as a helpful concept.

While learning something of the CoE through encounters in the institutional environment, what do we learn about the HEI? Our conclusion must be, rather surprisingly,

that Stafford Beer's Iron Maiden remains intact. A paradox then is the experience of the CoE with that of the Weberian and autopoietic view that we become entrapped within the institution as a source of security. However, in this case, the CoE narratives suggest a failure to find an entry point or truly embed and 'find comfort' in the institutional environment. Of interest then is the CoE's potential to offset this ambivalence by finding a level of autonomy, establishing an internal culture and activating a CoE level information system.

These findings align closely with Whitehead's ontological view of asymmetric relationships punctuated by inexplicable 'events.' That is, the CoE as an organising form 'experiences' the HEI environment rather than having any real inter-organisational interaction with the HEI. This is what we might expect in a 'research intensive university.' However, in general, CoEs that experienced benign neglect in the institutional environment fared very well. Those who went out to forage for information in the institution returned empty handed, but often found CoE friendly networks as a bypass. CoEs which appeared to be institutionalising, in fact appeared to establish effective tactics of managing the institutional environment - in network terms, by 'protecting the network from congestion.'

However, CoEs also experience internal challenges, as related in the narrative of 'the problem children.' Of interest too is the prominent narrative of 'wrangling the CIs' which, in some cases, inter-relates with the nature of their 'home' institutional environment. A review of these challenging cases suggests that interdisciplinary centres may be more prone to this challenge. This case aligns with findings of interdisciplinary centres highlighted by Borlaug and Gulbrandsen (2018). Although interventions may not be of value - as shown in the fact that CoEs that were left alone could flourish - understanding the case of interdisciplinary CoEs could be of importance at the point of establishment. Although CoEs across the programme demonstrate potential to form into a range of types, typically CoEs which become locked into more formalised processes, institutionalisation may set in. One particular finding of interest is the narratives of relative dissipation of these CoEs, while more cohesive CoE narratives described a cultural memory as part of their legacy.

No one model prevails. However, based on the narratives, CoEs which 'thrived' had strong Co-Leads. They describe a period where the small world of the CIs extended to form a small world with the Professional group. From there they established the next layer of the Centre via the CIs and professionals at the node level. Retaining the small world was also achieved by adding new members to governance groups to allow for equity. By allowing younger scientists opportunities, and generally enabling a sense of mobility through the CoE, the sense of the small world - not too connected, not too random - is retained. In network terms the information handling potential of a CoE with strong Co-Leads could also be the most important factor of the manner of the CoE's emergence and self-organisation.

Where the information handling is distributed, rather than delegated, the network-like nature of the CoE appears to have the most effective way of forming.

Although the CoE Programme may institutionalise further over time, the CoEs appear immune as a population to become homogeneous. Firstly, they are often insulated, intentionally or otherwise, from the institution. Secondly, they abhor institutional work, but generate their own policy where there is an absence of policy and where they see a need. Thirdly, the growing professional network is often a fellow comrade in the organising of science, rather than the professional elite which DiMaggio and Powell suggest work to formulate networks as bureaucracies. Even node 'administrators' might be allocated to research portfolios, rather than to roles aligned with institutional processes, such as seen in more traditional 'research management' roles within the core institution. If we see this group in the mold of the legacy of Henry Oldenburg, such advocates can only help add to the wealth and network development of science. Through a role as a 'network authority', as evident from some narratives, professional leads in CoEs may also be augmenting the network-like form of the 'invisible college.'

Shifting the Vocabulary

The research affirms a need to 'shift vocabulary' in considering relationships between complex organisational forms by bringing together the concepts of neo-institutional theory and network science. This important challenge is noted in drawing together a suitable lexicon via neo-institutional theory and allowing a connection with descriptors in network science which captures views of complex systems. As Watts and Newman both note, the challenge of vocabulary within network science and across related disciplines also poses difficulties. In mapping network-like terms across institutional theory and network science to develop the Open Architecture Framework I have aimed to better marry social theory and insights from phenomenological studies. This approach brings together existing well-noted sociological terms, such as 'the Matthew Effect' and its equivalence with 'preferential attachment', with other findings which suggest relevance for further insights into institutional and network-like organisational forms. This forms a beginning of a translation process to create access to network science via neo-institutional theory.

Applying this new vocabulary to the ARC's CoE programme may have relevance to how CoEs are 'valued and recognised.' While the programme has used terms - such as 'node' - to emphasise the inter-institutional nature of the CoE, this research suggests a hierarchical view of organisational development fails to capture learnings from the CoE. In

considering the Research Centre as a subordinate in the wider institutional environment, we can mistakenly suggest that 'the CoE plays a role relative to the HEI', that the 'HEI acts as a parent', that the 'early CoE is a type of startup', that 'the CoE is configured as teams' and so on. What was particularly important to note is that the contributors kept to their own descriptors in assigning attributes of 'what a CoE is' in ways that distinguish the form from the institution. This ontological view, that the CoE can be truly seen to develop a life of its own, offers opportunities to provide learnings through a language that more directly considers emergence and self-organisation.

As the findings identify paradoxical encounters rather than any clear case of inter-organisational CoE-HEI relationships, there remain two questions for research policy: firstly, how might funding bodies and HEIs act to assure adequate support for 'their' CoEs? and secondly, how can CoEs in their formative phase be better enabled to navigate the institution? Both a 'light touch' connection to the HEI executive and a structurally 'higher' insertion in the institution (typically at faculty rather than department level) appear important to the CoE. Policy makers could recognise that CoEs act as novel 'incursions' into the institutional environment which are information seeking.

Most institutions actively seek to provide suitable 'space' for the CoE. Provision of an environment where the CoE can also establish autonomy and a culture of working can also have value in delivering collaborative benefits. However, in cases where CoEs are bringing together highly novel interdisciplinary initiatives, an environment which enables a productive 'small world' of CIs may be important for assuring the CoE achieves that sense of Gestalt.

In the case of navigating the institution, the professional grouping of the CoE can be read as a true complement to the research system rather than as equivalent to research administrators within the HEI. In neo-institutional terms, CoE professional leads do not readily 'plug into' to any institutional professional grouping, but seek new network-like approaches to support their distinct needs. This effort, which also seeks to alleviate institutional work in favour of research activity and network-making, could be granted more recognition. Since emerging networks across the ARC CoEs are now evident from the narratives, further understanding of the professional networks and the CoE Programme may be of significant importance.

For both HEIs engaging in the CoE Programme and the CoEs themselves, the balance between institutionalising and retaining the CoE as a more network-like form is an ongoing tension. This can also be considered in relation to how Research and Professional Leads themselves co-navigate these spaces. From these findings, recognising the pluripotential nature of the CoE could help decouple the CoE Programme from the more

corporatised language of the HEI. Although the HEI may adopt new network-like terms to add to their institutional language, there is evidence that HEI executives can also engage in processes in ways that celebrate the network-like potential of the CoE.

In any further exploration of the network-like forms of organising, this research proposes that combining both institutional theory and network science offer greater opportunities for understanding the complex system of science in the institutional environment. As theoretician Mark Newman found from his brush with the dolphins of Doubtful Sound, embracing an interdisciplinary approach which engages with the social sciences could also allow theorists to get out and "…get their feet wet" (Oxford Institute, 2016).

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APPENDICES

APPENDIX I LITERATURE MAP – GUIDING THEORETICAL PERSPECTIVES

Sociological view / Period	Sociobiological / ecological	Socio-psychological / behavioural	Socio-generative /epistemological	Socio-constructive / functional	Socio-Economic / rational	Socio-Technical / operational
Enlighten-ment	**Humboldt** **1796-1857** *Cosmos: A sketch of a physical description of the Universe*	**Rousseau** *Discourse on Inequality (1755)*	**Immanuel Kant** *Critique of Pure Reason (1781)*		**Adam Smith** *The Wealth of Nations (1759)*	
Classical sociology	**Charles Darwin & Alfred Russell Wallace** *On the Origin of Species (1859)*		**Auguste Comte** *A general view of positivism* *[Discours sur l'Esprit positif 1844]*		**Karl Marx** <u>*Economic and Philosophic Manuscripts of 1844.*</u>	
	Henri Bergson *Creative evolution (1907)*	**Sigmund Freud** *Studies on Hysteria (1895)*	**Emile Durkheim** *The rules of sociological method (1883) Suicide (1897-8)*		**Max Weber** *The Protestant Ethic and the Spirit of Capitalism (1904)*	
Modern	**Ludwig Von Bertalanffy (1968)** *General Systems Theory: Foundations, Development, Applications*	**Vygotsky (1934)** *Thinking and speech* **Michel Foucault (1969)** *The archaeology of knowledge*		**Berger and Luckmann (1966)** *Social Construction of Reality*	**Peter Drucker (1950)** *Landmarks of Tomorrow: A report on the new 'postmodern' world*	**Ronald Coase (1937)** *Theory of the Firm*
Post Modern	**R Glassman (1973)** *Persistence and Loose Coupling in Living Systems* **Karl Weick (1976)** *Educational organisations as loosely coupled systems*	**Jean Piaget (1974)** *Genetic Epistemology* <u>Karl</u> **Popper (1974)** *Objective Knowledge, An Evolutionary Approach*		**Thomas Kuhn (1962)** *The Structure of Scientific Revolutions*		**Ronald Coase (1972)** *Industrial Organisation: A Proposal for Research*
		Pierre Bourdieu		**Anthony Giddens (1984)** *The Constitution of Society*		

Sociological view / Period	Sociobiological / ecological	Socio-psychological / behavioural	Socio-generative /epistemological	Socio-constructive / functional	Socio-Economic / rational	Socio-Technical / operational
		In *Knowledge and Control* and *Control* **(1971)** *Homo Academicus* **(1984)** St afford Beer *The Brain of the Firm* **(1981)**				
	Maturana and Varela a **(1980)** *Autopoiesis and cognition: the re* **Robert Birnbaum** *The cybernetic insti Toward an integration of gov*	*alization of the li* **(1989)** *tution: ernance theories* *ving*	**Paul DiMaggio and Walter Powell (1983)** *The Iron Cage revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields.* **Lynne Zucker (1986)** *Institutional Theory*			
Millennial	**Niklas Luhmann (1995)** *Social Systems* **Frederick Bates (1997)** *Sociopolitical Ecology: Human Systems and Ecological Fields*			**Ostrom (1990)** *Governing the Commons: The evolution of institutions for collective action*	**Wanda Orlikowski and Daniel Robey (1991)** *Information technology and the structuring of organisations*	
	Seth Abrutyn (2012) *Towards a Theory of Institutional Ecology: The dynamics of macro structural space*	**Nowotny, Scott and Gibbons (2001)** *Re-thinking Science, Knowledge and the Public in an Age of Uncertainty* **Altbach (2004)** *Globalisation and the University: Myths and Realities in an Unequal World* **Bruno Latour (2005)** *Reassembling the Social: Actor-Network-Theory*		**Robert Goodin (Editor) (1996)** *The Theory of Institutional Design*	**Charles Lindblom (2001)** *The Market System*	**Autio, E. and Thomas, L. (2014)** *Innovation Ecosystems: Implications for Innovation Management*

Legend: **Author (Year First Published)** *Monograph /* Article

APPENDIX II INORMS FOCUS GROUP STUDY REPORT

From a report to the
Australian Research Management Society (ARMS) and
Association of Research Managers and Administrators (ARMA, UK)

FOCUS GROUP
SESSION
INORMS2018

MEGAN POWER

Contents

List of Tables and Figures

Report by

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INORMS2018 FOCUS GROUP

Signs of life? Tapping into research professionals' perspectives on the Research Centre role in universities.

Synopsis

A focus group session hosted by the INORMS Conference 2018 offered new insights into the range of interactions performed by research professionals, as well as capturing their perceptions of the function of Research Centres in Higher Education Institutions (HEIs).

By tapping into the views of research professionals, the focus group aim was to contribute insights into how Research Centres in HEIs apparently act as both an institutional form and as a node in global networks. The focus group asked contributors to describe up to five interactions based on a three month work period of their choice and to map these against a set of suggested institutional groups. They were then asked to respond to a pilot survey.

The eighteen contributors in the focus group represented a spectrum of North-South research management experience with backgrounds as directors and managers as well as newcomers to Research Centre establishment and development in HEIs.

Although this research primarily aims to inform approaches in the field of institutional studies, a number of findings emerged which may support an understanding of the research professional role more directly. For example, the term '**new**' was frequently used when describing interactions of importance. Contributors also identified most of their interactions as focussed toward the core HEI or a Faculty / Department and their interactions with individual researchers within the HEI were particularly high.

In response to a set of semantic questions, contributors were divided as to whether a Research Centre could be described as 'more dependent on' or 'more independent of' the HEI. However, regardless of their view of independence, contributors were more likely to consider the Research Centre as; able to take a creative approach in research development, globally oriented and responsive to the policy environment.

While the number of contributors to the pilot survey was lower (n=12) than the contributors to the interactions session, this analysis of the focus group output suggests 1) that the use of semantic questions presents an effective means to differentiate perceptions of relevance to institutional theory with this professional group and, 2) possibly, that research professionals perceive the place of Research Centres in ways which contrasts with their day-to-day interaction descriptions.

While the focus group output suggests research professionals may be focussed on institutional interactions at the micro level, they may simultaneously perceive the place of the Research Centre in different ways at a more macro-level.

While some findings will not come as a surprise to the research professional community, this contribution has greatly supported the formative stage of this research project and helped frame the next phase which may have benefits in informing future research strategy as well as supporting the emerging role of research professionals in the global research environment.

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1   Background

Contemporary institutional theory has captured the attention of a wide range of scholars across the social sciences and is employed to examine systems ranging from micro interpersonal interactions to macro global frameworks. (Scott, 2004)

The focus group activity, kindly supported by Monash University, Warwick University, INORMS and ARMS, was conducted during INORMS2018 in Edinburgh and forms part of an overall study into entitled **The Institution and the Network**: **The case of the Research Centre role in Higher Education Institutions and Global Research Networks**.

The research considers the apparent duality of a Research Centre's function as both an institutional entity of the Higher Education Institution (HEI), and as a node for research connections within a rapidly changing networked environment. By taking multiple perspectives of the role of the Research Centre as a whole, the research aims to contribute to institutional theory as well as to inform future Research Centre development and support those working in Research Centre related roles. In particular, the increasing professionalisation of research management, as a recognised specialism in its own right, signifies the importance of this field and the potential value in seeking input from research managers to better understand the 'global research system'.

While numerous researchers have considered Research Centres and their relative impact, particularly in comparison to the traditional delivery of research by university departments and industry engagement, these have often relied on output measures of research using bibliometric analysis and / or drawn on the input and views of Research Centre directors. By taking a sociometric approach, which reconsiders social connections to explain research outputs (Crane, 1977), the focus group was designed to enable a broader group of participants to describe and share their interactions in reference to their role/s and relationships with Research Centres in HEIs.

2   Method

The Focus Group aimed to gain an insight into the effectiveness of data capture to inform the research development in three ways;

- Direct engagement of participants for contributions of their interactions in reference to their role and relationship with Research Centres in Higher Education
- Consideration of the use of email interactions in capturing interactions of research professionals.
- To pilot a series of survey questions to ascertain the suitability to develop a wider survey for this research appropriate to those working in Research Centres.   By conducting this focus group at an international event, there was also an opportunity to test whether the translation of ideas and concepts developed through the research to date resonated with an international group of research professionals.

Participants were recruited from those who had self-selected to attend the workshop event at INORMS. The INORMS conference team generously forwarded information about the data capture component of the workshop as well as ethics requirements and consent forms to prospective participants on behalf of the researcher.

3   Running the session

3.1   . Introduction

The focus group session began with an introductory presentation of the literature review findings to date. While there was no direct outline of the research proposal, the presentation 'primed' the audience by giving some background to the research project and providing a review of the Research Centre studies which has informed this research to date. At the conclusion of the presentation attendees had the option to leave if they chose not to participate in the focus group component. In all 18 participants remained and 17 contributed actively in the session.

3.2. Immersion Tool Demonstration

The Immersion tool developed by (Hidalgo, Smilkov, & Jagdish, 2013), was used to demonstrate potential for individuals to visualise their personal social networks by mapping email metadata.

As part of the presentation, an example of the Immersion output of email interactions was shown to give an example of the way individuals could consider their own social networks. Participants were invited to view this site if they chose to do so.

3.3   Capturing Interactions

In addition to the session information, each participant was provided with post-it notes to record their interactions. Participants were asked to;

a. Select a three month period of relevance when considering their interactions. They were asked to record this period and reason for selection on their participant form (see Appendix I).
b. To record three interactions, using one post-it note for each separate interaction. An example was given.
c. Participants were then asked to discuss their three interactions with those sitting nearby and to compare their experiences. After allowing about seven minutes for discussion,

participants were asked to record another two interactions, using one post-it note for each interaction.

d. At the conclusion of this session each person should have recorded five interactions, giving potential for up to 80 interactions contributed by the group.

3.4. Mapping interactions

During the discussion I posted up a series of group headings on the walls. These were – 'THE HEI CORE', 'THE HEI FACULTY/ DEPARTMENT', 'THE RESEARCH CENTRE', 'RESEARCH CENTRE PARTNER', 'RESEARCH CENTRE SPONSOR', GOVERNMENT, OTHER.

a. Participants were then asked to look at these groups and to 'catalogue' their interactions to the closest group by placing their post-it notes in these groups.

b. Participants were invited to look at the interactions noted under each grouping.

c. These groupings were then photographed.

Figure 297.

Interactions posted in relation to organisational groups

3.5. Remapping interactions

a. I then removed the interaction post-its from the wall as they were posted and gave a bundle of interactions to each discussion group of 2-5 people.

b. I asked each discussion group to look at the interactions and see whether they could arrange them in a different way – that is – were there any other groupings evident? Some photos were taken to note how the groups reviewed the interaction post-its.
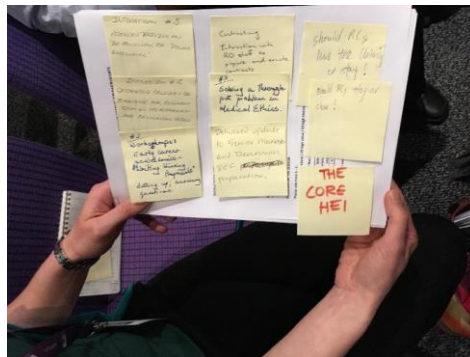
Groups review the Interactions to look for other possible groupings

a I asked the groups to make new headings for their groupings on a separate post-it note and to post up the interactions under these new headings.

b One group noted the group size and suggested regrouping based on whether the interactions were; *1:1*, *1:group* or *general transmit interactions*. Another group suggested regrouping based on the type of activity – eg such as whether the interaction related to type of engagement, eg *communicating* with stakeholders or *reporting* to funders. The third group did not suggest any alternative grouping for the interactions they reviewed.

c The new groupings were then posted up and photographed.

Figure **298**.
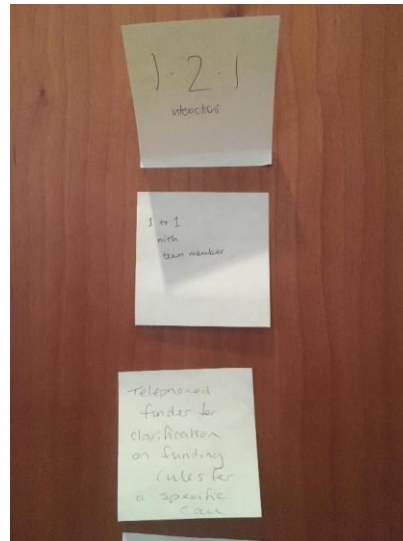
Alternative groupings for the interactions suggested by participants (example)

3.6. Pilot survey and Session Close

a. Participants were then asked to complete the pilot survey and to provide any feedback on the session via the feedback section on the form.

b. To close the session I then provided some more information about the plan for the research and presented the concept slide of considering the Research Centre within this complex environment of operating between the institution and the network.

4 Reflection and participant feedback on the session

The focus group session was time constrained by a second speaker which meant the 'remapping' section was shorter than intended. However, at least two groups were able to do this within the time. The INORMS Chair allocated to the session was very supportive throughout the activity.

Unfortunately, the WiFi at the venue only allowed a small number of participants to use the Immersion tool. However, those that were able to view their interactions were able to share and discuss their observations with others during the session.

Overall the group was highly participatory, with contributions to the session readily offered and there were no concerns expressed about the nature or purpose of the activity. Minimal additional information was needed for participants to readily undertake the suggested tasks and participants engaged well when sharing information. Two participants were less engaged and it was not immediately apparent why this was the case. Once again the time constraint meant it was difficult to speak to each of the small discussion groups and answer all questions they may have had. Fewer participants responded to the pilot survey on the day although one subsequently forwarded a response by email. This may have been due to limited time to cover this with the participants and check they had an opportunity to complete it.

The average feedback score for each component of the session where 1 represents 'of little value' and 5 represents 'highly valuable' is shown in Table 1. The feedback suggests that the opportunity to write, share and map interactions is highly valued when compared to receiving information and completing the survey.

Table 1. Participant feedback summary

Session	Introduction	Writing Interactions	Sharing Interactions	Mapping interactions	Pilot survey
Respondent rate % n=18	70%	70%	70%	70%	47%
Average response/5	3.6	3.9	4	3.9	3.6

4.1   Logging the contributions

4.1.1. Use of the Immersion online tool

The approach of eliciting interactions through the focus group was considered alongside the potential to use online tools which capture interactions in a dynamic way. This may allow the scaling up of data gathering in this area and enable a view of the temporal nature of Research Centre development before research outputs can be measured. However the use of online tools in a group environment / workshop setting may be challenging and needs to be considered more practically.

4.1.2. Post-it note interactions and 'Group Sets'

a.   The post-it notes were all transcribed into an Excel spreadsheet with each interaction forming a record. All notes were transcribed as written. In total 80 interactions were captured and recorded.

b.   The interactions were then matched to the different groupings as part of the mapping exercise. Based on photographs the grouping 'attributes' were noted in relation to each interaction against the interaction record.

c.   The matches included both those set by the researcher – e.g. the organisational groupings and the sets created by the participants.

d.   As each participant had only mapped a subset of the interactions – all interactions were reviewed and the closest match was made for the participant generated sets of interactions.

4.1.3. Respondent profiles and baseline information

The respondent profile information and baseline information was transposed from paper records to an Excel Spreadsheet. a. Thegroup composition was as follows

i. Gender Ratio: 0.4:1 Male:Female (indicative only – as noted by researcher)
ii. Regional Profile:

Northern Hemisphere: Europe (includes all UK) = 70.5%
Southern Hemisphere: Aus+NZ+SA+ Singapore = 29.5% iii. Managerial Level
Director equivalent: 17.6% Manager equivalent = 64.7% Administrator 17.65

Figure 4. Focus Group participant profiles by institutional group
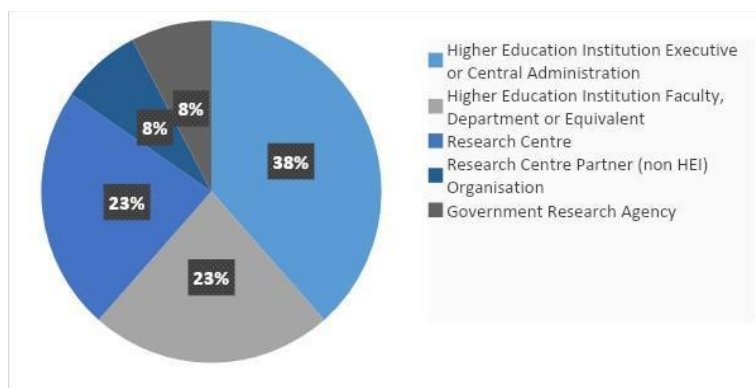
5. Survey responses

a. The responses submitted on paper were transposed back into the original Google form created for the survey. One participant completed the survey online rather than on paper.

b. Twelve (12) responses to the survey were received on the day with a further response returned by email after the conference.

5.1 Interactions analysis

5.1.1. Analysis of contributions

Participants produced up to five interactions each, giving a total of 80 interactions for the analysis.

Participants were readily able to describe their interactions and then map their interactions in relation to the organisational groups suggested by the researcher. The output suggests that the predominant interactions were directly with researchers, followed by interactions with the Core HEI. 'Other' interactions included HR related functions, such as job interviews and professional development. While interaction descriptions allocated to 'other HEIs' were very low (2%), on closer review a number of descriptions allocated to 'other' (16%), included both other HEIs and other partner organisations.

Figure 5. Proportion of interactions by organisational group
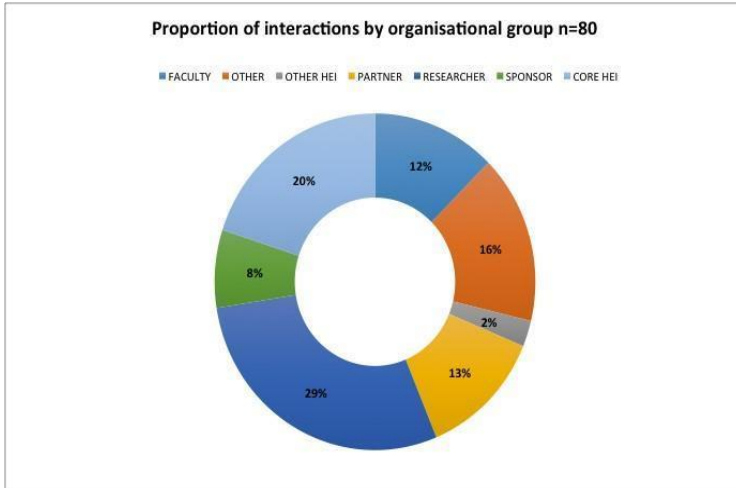
By allocating the interactions based on their descriptions as either an Internal Interaction – i.e. within the HEI (assuming all researchers referred to were internal), the interaction profile provided was estimated as 65% internal and 35% external.

The participants were able to review the interactions and consider different sets. The output in Figure 6 below gives the interactions as arranged into sets developed by one participant group. Based on their grouping the same set was applied to all interactions by the researcher. This was relatively straightforward given the interaction descriptions. The interactions suggest a relatively high level of interactions with groups. However one-to-one interactions with researchers was noted as high, suggesting important engagement between research professionals and academics

Figure 6. Relative % of contributions based on participant regrouping
of interactions


301
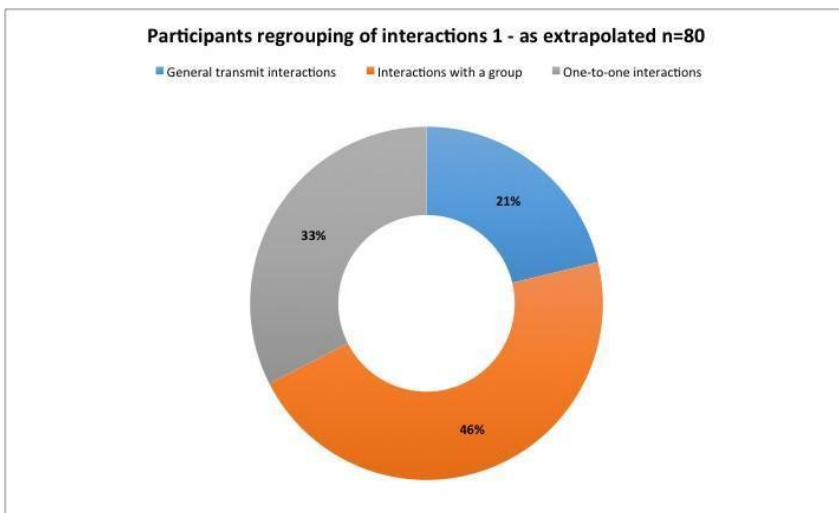
5.1.2. Cluster analysis

The interactions dataset was imported into NVivo11 Pro for Windows for further qualitative analysis. The purpose was to explore the interactions data and identify any other areas which may have relevance for development of the next stage of the research. Basic exploration looked at word frequency, then selected stemmed words as the next stage query for terms of interest.

Unsurprisingly 'research' and its close (generic) synonyms eg; researcher, investigator, academic, were the most prevalent, appearing 39 times in the 80 contributions. However, of interest was the relatively high prevalence of the use of the word '**new**' which appeared 18 times in the 80 contributions – second only to the terms relating to research.

The cluster analysis below provides some context to the use of the term 'new'. This output demonstrates the number of people-to-people interactions and the range of interaction types which relate to these '**new**' activities.

'**Meet**' or '**meeting**' were the next most frequent words and the cluster analysis also assisted in highlighting stakeholders through the '**Meeting with**' branch of the cluster analysis for this term. This showed evidence of the breadth of interactions recorded by the group.

Figure 7. Cluster analysis for term 'new' based on 80 interactions

302
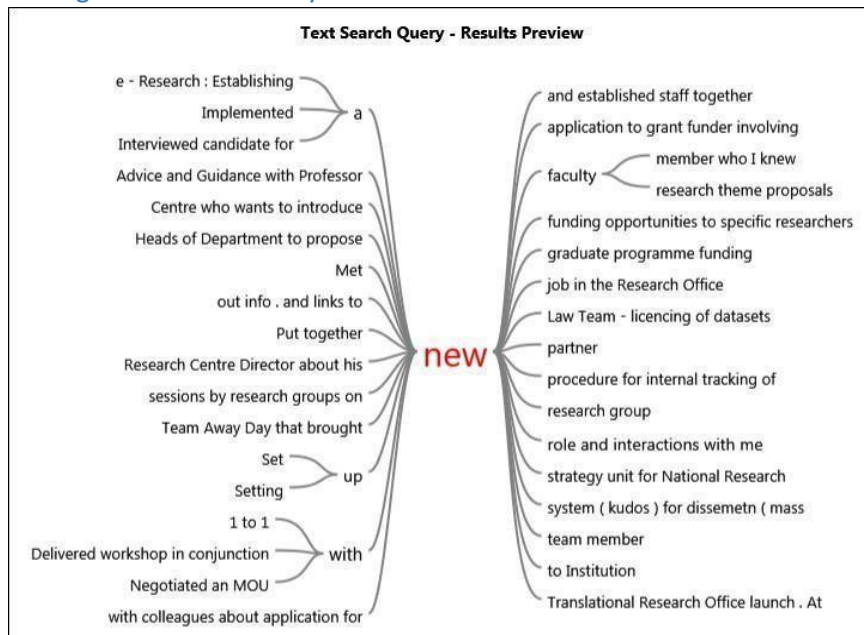
6   Pilot Survey Analysis

## 6.1. Participant profile and interaction questions response set

A smaller number of participants from the focus group responded to the Pilot Survey (13 out of 17). However, the respondent information was of value in assessing the potential relevance of the survey proposed for the next phase of the project.

Survey respondents were predominantly based in either a HEI central or faculty executive or administrative role. Around a quarter were based directly in a Research Centre and the remainder were in non HEI roles which supported the work of Research Centres in HEIs.

As shown in Figure 8 below, respondents were most likely to have had roles or experience associated with either the start-up or operational phase of a Research Centre, where 0 = no involvement to 5 indicated a high level of involvement. While all phases of the Research Centre development were noted, only one respondent had a high level of experience in scaling down or closing a Research Centre.

This indicates that, despite the small group size, a breadth of experience was present in the focus group session.

Figure 8. Roles and experience in relation to Research Centre development (n=13)
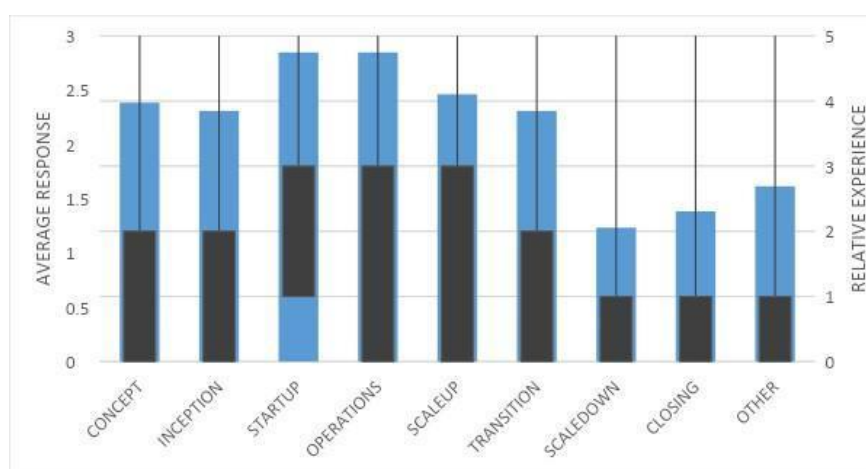
6.2. Rating interactions

In terms of internal (HEI linked) interactions, respondents were asked to rate the frequency of internal engagement from a set of HEI groups, where 5 = daily, 4 = weekly, 3 = monthly, 2 = occasionally, 1 = rarely and 0 = no interaction. As shown in Figure 7 below, the highest level of engagement was with '**resources and purchasing**' (mode=4) or grant administration (average response = 2.67)

Figure 9. Ratings for frequency of (HEI) internal interactions (n=13)
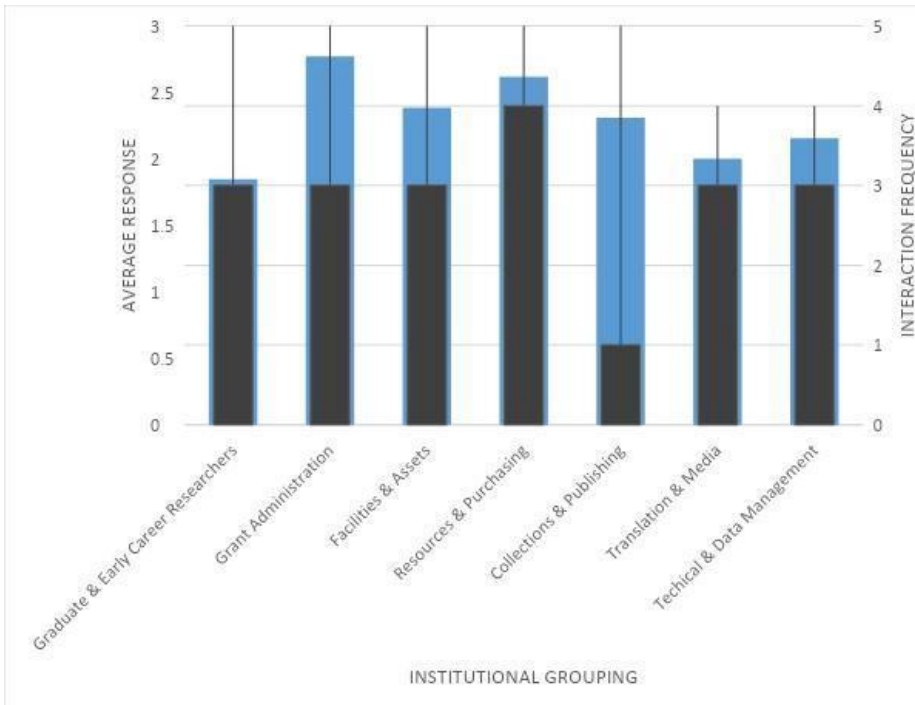
Respondents were also asked to rate a set of external groups in terms of the significance of their interactions with each group. A rating of 5 indicated a group the respondent considered to be highly significant. This response indicated '**researchers in other HEIs**' were the highest significant grouping, with '**industry**' and '**governing body**' of the Research Centre being the next most significant. Of interest is that other international groups were seen to be of lesser significance.

Figure 10. Ratings of significance of interactions with external groups (n=13)
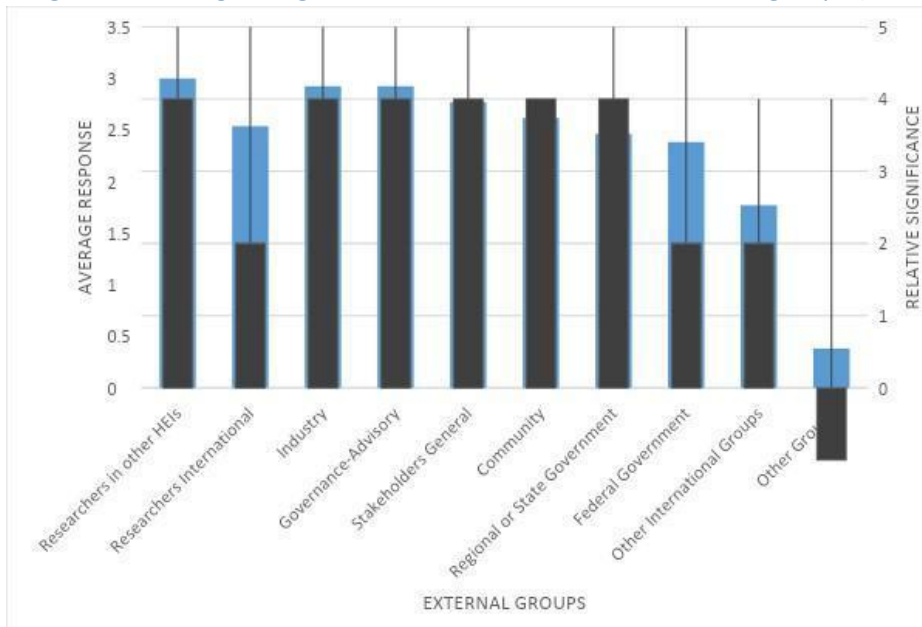
7. Semantic question set

The pilot survey included a set of five semantic questions which aimed to look at perceptions of the HEI and Research Centre relationships in ways which relate to institutional theory. Participants were asked to consider the view of the Research Centre as a whole in responding to these questions. A proposed indicator term related to concepts found in the institutional theory literature is given in the left column against each semantic question to highlight the relevance to each. These indicator terms were outlined indirectly to participants in the questions and in the introductory presentation. A summary of the semantic question set, which shows the parameters of the semantic questions and the related indicator derived from institutional theory, is shown in Figure 11 below.

Figure 11 Responses to semantic question set: n=12*

Indicator	More like this					More like this
Legitimacy	Independent 0%	33%	17%	33%	17%	**Dependent**
Embeddedness	HEI is a Home 17%	42%	8%	25%	8%	HEI is a Host
Autonomy	**Responsive** 17%	**50%**	25%	8%	0%	Constrained
Adaptability	**Creative** 25%	42%	8%	17%	8%	Systematic
Orientation	**Global** 33%	33%	25%	8%	0%	Local

*nb 1 respondent did not respond to 4/5 questions as these were 'non applicable' and this response is not shown. However the need to account for participants who engage indirectly with Research Centres is noted from this case.

There are challenges in making sense of the relative importance of these responses. As each response selected is based on a nominal 'view' the respondent applies between the suggested parameters, the actual distance or perceived intervals between the given parameters cannot be assumed to be equivalent (Harwell & Gatti, 2001). In this case each response is considered ordinal in nature, rather than scalable and potentially 'normal' in their distribution, and these considerations need to be taken into account in further analysis.

However, by assigning the 1 - 5 scale as an adequate indicator of the prevailing view of the group, the frequency response output shown in Figure 11 indicates areas for further exploration. The raw data suggests the Research Centre was viewed overall as 'acting' more toward the responsive (67%), creative (67%) and global (66%) end of the parameters offered, while respondents viewed the Research Centre as relatively more '**dependent on**' (50%) and more '**at home**' in the HEI (59%).

If we hypothesise that any given individual might behave consistently regardless of the question type, that is, be more likely to give a more neutral response each time or be more likely to respond more decisively in one direction, then we might not expect to see more (or less) polarity between responses. Apart from the terms – independent vs dependent – which could be considered to exist on a continuum - the other hypothesis being considered in this case is that the semantic parameters offered should not have an inherently greater value over the other, that is, 'more global' should not be regarded as having a greater value than 'more local'.

Of interest then is the clear variation in the weight of responses across all of the respondents, which indicates either that respondents perceive some parameters to be more 'evident' than others, or that some suggested parameters are perceived to have a greater semantic (or other) value over another.

7.1. Statistical analysis of semantic question set

As noted above, the responses to semantic statements can be considered non-normal in their distribution and require a non-parametric test be applied in determining any statistical significance. While there is potential to transform responses to ordinal questions into an integer scale in order to treat the dataset in the same way as potentially normal data (Harwell & Gatti, 2001; Wu, 2007), for the purposes of initial exploration, the aim is to consider the benefit of using this type of enquiry in the wider research project.

In addition to comparing the overall responses, the first response by each individual was then paired with their subsequent responses for analysis. This was to determine whether those who considered the Research Centre more or less independent, were able to distinguish their responses in subsequent questions (ie to test the questions) as well as to consider a Research Centre to demonstrate other attributes associated with independence.

The anchoring question for the semantic set, against which further responses were compared, related to the perceived level of autonomy of the Research Centre in relation to the HEI. This was:

In terms of the Research Centre's potential to interact independently with other organisations would you consider the Centre to be: 1 = Highly independent from the HEI – legitimate in its own right => 5 = Dependent on the HEI for legitimacy.

Notably, no respondents rated the Research Centre as highly independent in its own right, and the remaining responses were split across moderately independent to moderately dependent on the HEI.

The second question, which asked a similar question related to independence, but with a more subtle aspect, looked for perceptions of embeddedness of the Research Centre within the institution.

In terms of the HEI role in supporting the Research Centre overall, do you consider:

1 = The HEI provides a home for the Research Centre => 5 The HEI acts as a Host for the Research Centre

These responses would fit with perceptions of relevance to institutional theory that an entity, once established, is perceived as more independent and would be expected to use the institution as a base or that the relationship is more host-like. In contrast, an entity which is perceived as more dependent might be expected to use the institution as a home and be more embedded.

As shown in Figure 12 below, paired responses to Q1 and Q2 for the same respondents suggest that those who considered the Research Centre as highly - moderately dependent, may be more likely to consider the HEI as a Home for the Research Centre. Conversely respondents who rated the Research Centre as moderately independent, noted the HEI had a neutral or more Host like role. However two respondents went against this trend.

Figure 12 Paired ratings for legitimacy vs embeddedness by survey respondents (n = 12)
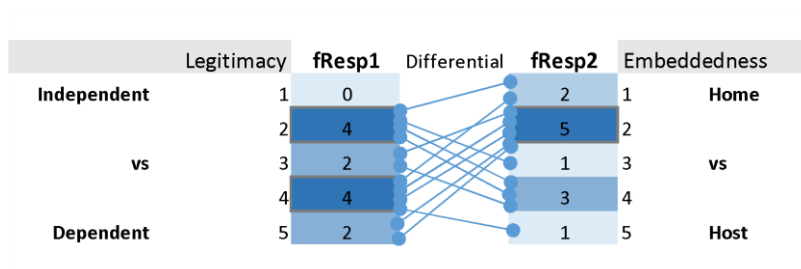
This visual analysis of paired responses in relation to the rating for independence vs dependence with the other semantic questions suggests respondents overall tended to perceive the Research Centre as more responsive, more creative and more global, regardless of whether they considered the Research Centre to be Independent of or Dependent on the HEI. A full outline of the paired responses is given in Appendix IV.

Meek, Ozgur, & Dunning (2007) suggest either a standard t-Test or a Wilcoxon Signed Rank Test could be suitable for measuring non-parametric responses to a Likert scale in small sample sizes (between 5-15 paired samples), such as in this case. Although semantic questions differ in their purpose to Likert scale questions, they are considered to have a similar ordinal character and a number of potential approaches to examine outputs of this type could be applied (Lalla, 2017).

For simplicity the scales selected by the respondents were treated as true integers and a Wilcoxon Signed Rank test was performed by hand as outlined by O'Loughlin (2017), as the data type indicates a nonparametric test is more suitable in this case. The hypothesis (H0) being tested was that there should be no significant difference between the responses made for Q1 to subsequent similar questions by the same individual.

The two-tail test revealed no statistical significance in the Wilcoxon Signed Rank test as shown in Table 2 below. However, a t-Test assuming equal variance performed in SPSS on the paired responses, suggests significance at the two tail level (p<0.05) in responses for Q1 independence vs Q3 the level of policy response and Q5 global orientation. The t-Test output is shown in Appendix IV.

Table 2. Analysis of response ratings for independence compared with three other semantic statements

		Test	Responsive	Creative	Global
		T-	57	61.5	63
		T+	21	16.5	15
		Wstat	21	16.5	15
2-tail test	n=12	Wcrit	13	13	13
p<0.05	Wstat<Wcrit		No	No	No

8.   Discussion of findings

The Focus Group session at INORMS provided a valuable opportunity to be informed by an expert group on the perceptions and actual interactions of those engaged with Research Centres in HEIs.

Despite some constraints in running the Focus Group within a Conference setting, the number of participants and the level of contribution provided the necessary breadth and depth to inform the next stage of the research project.

An analysis of the outputs also revealed additional insights and suggested approaches of relevance to the research development. Although conference delegates would not be surprised to learn the interactions suggest research professionals conduct a wide range of activities and engage across a broad group of internal and external stakeholders, there were some further insights which gave a richer picture of the role, particularly in relation to overall research development capacity.

The use of the pilot survey and the interaction activity together revealed complementary, as well as potentially contradictory information, which suggests value in using different methods to gain an overview of the research management role and individual perceptions of the Research Centre function.

As shown in Figure 6 the high use of the term '**new**' in the interaction descriptions relates to a range of activities from employing and orienting new staff to introducing new systems or other initiatives. This potentially correlates with the relatively high proportion of respondents who had worked in the early phase of a Research Centre's establishment. As all respondents suggested at least some experience in the initiating phases of a Research Centre, they might reasonably be at the front end of initiatives and new activities. Alternatively, it may be that respondents are more likely to offer cases of 'new' interactions.

Both the interactions and the survey responses suggest that Research Managers are highly engaged with researchers both from within their own institution and with those in other HEIs. A range of researcher roles were noted in the interactions descriptions and interaction with researchers in other HEIs was noted as highly significant in the survey responses (Figure 8). This information suggests the capacity contribution made by this professional group as active brokers of relationships and support for research development. This capacity building activity conforms with policy which supports Research Centre funding in Australia, where formation of Cooperative Research Centres is noted to "… support research over longer timescales, sustain multiple collaborations and help universities to maximise their impact…" (Australian Government, 2011, p31.)

A potentially counter intuitive finding was the high proportion of survey respondents who considered the Research Centre to be highly global in its orientation (Figure 11), while the interactions with external groups indicated a relatively low level of significance of interaction with international researchers and other international groups (Figure 10). Respondents were also more likely to consider the Research Centre to be creative in the approach to research development and likely to consider the Research Centre to be able to respond to the policy environment. These views appeared to be independent of whether respondents considered the Research Centre to be dependent or independent of the HEI.

While the terms '**global**', '**responsive**' and '**creative**' may potentially be viewed as more positive terms over '**local**', '**constrained**' and '**systematic**', which could favour their relatively higher selection, the terms '**independent**' vs '**dependent**' and '**home**' vs '**host**' did not show any similar bias. In these cases, the group had a broader view of the Research Centre in relation to the HEI. While no respondents considered the Research Centre to be '**highly independent**' of the HEI, the level of perceived dependence did not affect the perception of the Research Centre's potential to operate in ways that could be considered to be more autonomous and outward looking.

In terms of the individual actions of the respondents, and the role of the research professional in affecting a wider network, it was clear that a capacity building role both within the institution and more widely via professional networks may be prominent activities. While these responses may be skewed – particularly given all participants were attendees at an international conference - this apparent focus which has potential to build institutional research capacity, while linking out to a wider professional and research network, has a particular bearing on the institutional-network space and is ripe for further investigation.

(Please see the main reference list for citations used here.)

APPENDIX III CoE STUDY INTERVIEW QUESTIONS

ARC Centre of Excellence CD-COO Pre-Interview Survey & Interview Guide

This survey forms part of a research study entitled: The Institution and the Network: The case of the Research Centre role in Higher Education Institutions and Global Research Networks. The study is being conducted by the Faculty of Information Technology, Monash University, Australia and Warwick Business School, Warwick University, UK.

You will have received information in an email sent inviting you to participate in this study. The email outlines the purpose of the study and asks your participation by responding to this survey with the option to also contribute to a one-to-one interview. The survey asks you to provide some information about your role and to respond to a set of statements about your experience and view of the wider role of the ARC Centre of Excellence. The survey should take no more than five-ten minutes.

By selecting the 'responding to this survey' box in Question 3 below we assume you have given consent for your responses to contribute to the study. The survey contributions will be anonymised and the survey analysis will not identify individuals or individual Centres of Excellence. Survey responses sent via this GoogleForm are stored in Monash University secure servers.

Subsequent to this survey you will have the opportunity to participate in a one-to-one interview. This will take between 30-40 minutes and we will ask you to read the project's explanatory statement and sign a consent form which has been sent with the earlier email before the interview is conducted. If you prefer not to participate further and / or would prefer to nominate another person to contribute to this study you can also indicate this in Question 3 below.

Chief Investigator
Associate Professor Henry Linger : henry.linger@monash.edu

PhD Candidate Researcher contact
Dr Megan Power : megan.power@monash.edu

*Required

1. **Email address** *

   _____

2. **Your full name**

   _____

3. **Please indicate your preferred level of participation in the project (please select any that apply)** *
   Tick all that apply.

   ☐ Responding to this survey

   ☐ I can be contacted to arrange a one-to-one interview

   ☐ I would like to nominate another person to participate in the one-to-one interview and will forward your contact details to them

   ☐ In principle I would be prepared to distribute an online survey link to my team to support the next stage of this project - please contact me with further information

Should you have any concerns or complaints about the conduct of the project please contact

Ref Project ID : 14086
Executive Officer, Monash University Human Research Ethics (MUHREC):
Room 111, Chancellery Building D,
26 Sports Walk, Clayton Campus
Research Office
Monash University VIC 3800

Tel: +61 3 9905 2052   Email: muhrec@monash.edu   Fax: +61 3 9905 3831

Centre of Excellence Information

Please provide information for the main Research Centre / Centre of Excellence which you will be referencing in your responses to this survey

4. **Name of the Centre of Excellence**

5. **Your role / title in relation to this Centre of Excellence**

_____

_____

Your involvement in research development

6. **For this Centre of Excellence, can you indicate your level of involvement at different phases of development. Please select one per row.** * _Mark only one oval per row._

	High Involvement	Moderate Involvement	Limited Involvement	No Involvement	Not applicable
Concept	◯	◯	◯	◯	◯
Inception / Business Case	◯	◯	◯	◯	◯
Start Up / Early Establishment	◯	◯	◯	◯	◯
Steady State / Operational	◯	◯	◯	◯	◯
Scaling Up / Next Phase	◯	◯	◯	◯	◯
Transitional / Review Management	◯	◯	◯	◯	◯
Scaling down	◯	◯	◯	◯	◯
Closing	◯	◯	◯	◯	◯
Other	◯	◯	◯	◯	◯

7. **Can you indicate your prior level of involvement in other research centres, research programmes or equivalent enterprises? Please select one per row.** * _Mark only one oval per row._

	High Involvement	Moderate Involvement	Limited Involvement	No Involvement	Not applicable
Concept	◯	◯	◯	◯	◯
Inception / Business Case	◯	◯	◯	◯	◯
Start Up / Early Establishment	◯	◯	◯	◯	◯
Steady State / Operational	◯	◯	◯	◯	◯
Scaling Up / Next Phase	◯	◯	◯	◯	◯
Transitional / Review Management	◯	◯	◯	◯	◯
Scaling down	◯	◯	◯	◯	◯
Closing	◯	◯	◯	◯	◯
Other	◯	◯	◯	◯	◯

The Centre of Excellence role and relationships

In answering the following set of questions, please note that the Higher Education Institution (HEI) means the lead HEI responsible for administration of the Centre of Excellence (the Centre). Please leave a question blank if you are unable to / prefer not to respond.

In answering - consider providing a response from your perspective of the Centre as an actor in the wider research system at the current time.

8. **How would you describe the Centre's current relationship to the HEI?** _Mark only one oval._

	1	2	3	4	5	
on the HEI	◯	◯	◯	◯	◯	t of the HEI

9. **How would you describe the HEI's current relationship with the Centre?** _Mark only one oval._

1   2   3   4   5

| Home for the | ◯ ◯ ◯ ◯ ◯ | Host for |

10. **Where do you see the Centre's current policy / strategic focus?** *Mark only one oval.*

| he wider icy / strategic t | ◯ ◯ ◯ ◯ ◯ | on the ation policy / t |

11. **How would you describe the Centre's current approach to research development?** *Mark only one oval.*

	1 2 3 4 5	
pproach	◯ ◯ ◯ ◯ ◯	n approach

12. **Where would you place the Centre's current geographical focus?** *Mark only one oval.*

	1 2 3 4 5
ıl	◯ ◯ ◯ ◯ ◯

13. **If you would like to make any general comment or clarify your responses to the survey please provide this here.**

_____

_____

_____

_____

_____

u
like to contact the researcher in relation to this project or would like to arrange an interview time please an Power
megan.power@monash.edu or phone or text +44 7494 881450

A copy of your responses will be emailed to the address that you provided

The Institution and the Network.

Interview Pro-Forma

Shaded area to be prepopulated for background by researcher

1. **Interview details**

1.1 Interview date / time taken:	Date:		Time (mins):
1.2 Interview method	In person		Via Zoom/other
1.3 Consent form complete	Yes		In part / No
1.4 Pre-interview survey complete	Yes	No	Response link:
1.5 Notes about interview set up			

Pre-Interview survey link : https://goo.gl/forms/dPtHwtEOWJiBWeAf1

2. **Research Centre (CoE) Profile**

2.1 Centre Name			
2.2 Year Established			
2.3 (ANZSRC) FIELD OF RESEARCH / DIVISION/S			
2.4 (ANZSRC) FIELD OF RESEARCH GROUP/S			
2.5 ARC Lead / Administrating HEI:			
2.6 Partner Organisations			
2.7 Notes about Research Centre			

3. **Interviewee Profile**

3.1 Interviewee Name:
3.2 Interviewee Organisational base: eg Research Centre; Lead HEI; Other HEI; Government; Partner Organisation; Other
3.3 Interviewee Institution / Organisation:
3.4 Notes about interviewee / institution:

4. **Interviewee Role:**

4.1 Your Role title:
4.2 Your Role level: eg Executive / Director / Manager / Other

4.3 Your most recent role (prior to this)
4.4 In relation to your current role, which stage/s are you / were you most closely engaged in in relation to the (this) Research Centre/s: *If a pre-interview survey has not been completed use this as point of introductory discussion if needed.*
• *the Conceptual / Early Development stage (before funding)*   • *the Inception / Implementation stage (at point of funding)*   • *the Start Up stage (at point of formalising governance and staffing etc)*   • *Scaling Up (at point of secondary funding)*   • *Transition (at point of review or other transition stage)*   • *Scaling Down (at point of funding period completion)*   • *Closing (at point of programme / enterprise closure)*

5. **Interviewee Personal Interactions** - *direction for questions:*

*5.1 Can you describe / give an example of a **frequent** interaction you have at a personal level, either within or outside the Research Centre?*

*5.2 Can you describe / give an example of a **significant** interaction you have had at a personal level, either within or outside the Research Centre?*

Prompts if needed:

Note that interactions can be formal or informal / routine or ad hoc / one off activities / person-to-person or socio-technical (eg sent email to Vice-Chancellor etc)

6. **Interviewee Perspective on Team Interactions** - *direction for questions:*

6.1 Can you describe what you consider to be the 'Centre of Excellence Team'?

*6.2 Given that grouping, can you describe / give an example of a **frequent** interaction the team has, either as a group within or outside the Research Centre?*

*6.3 Can you describe / give an example of a **significant** interaction the team has had, either within or outside the Research Centre?*

7. **Interviewee Perspective on Centre interactions**- *direction for questions:*

*7.1 Thinking about the **Centre as a whole**, including the researchers linked to the Centre, can you describe / give an example of a **frequent** interaction?*

*a **significant** interaction?*

APPENDIX IV CODING SETS (SAMPLE) FOR INTERVIEW ANALYSIS

Name	Files	References
INSTITUTIONAL LENS	12	1600
INSTITUTIONAL CHARACTERISTICS	12	1021
AUTONOMY	8	421
CULTURAL AUTONOMY	8	128
PERSONAL AUTONOMY	8	66
RELATIVE AUTONOMY	8	139
RULE_POLICY MAKING	8	88
INSTITUTIONAL THEORY	8	579
INSTITUTIONAL DESIGN	8	270
INSTITUTIONAL FUNCTION	8	41
INSTITUTIONAL RESOURCES	8	130
INSTITUTIONAL RULES	4	55
STRATEGY and PLANNING	8	37
INSTITUTIONAL ECOLOGY	8	309
INSTITUTIONAL ENVIRONMENT	8	251
CULTURAL ENVIRONMENT	8	149
SPATIAL ENVIRONMENT	5	21
NATURAL CODES	21	271
(EMERGENT) THEMES	21	243
I was employee number #1	11	
I'd be interested to know what others do	3	
If I'd known there was a death toll	3	
If the VC knew where we were it would be a miracle	10	
The Gestalt Greater than the sum of its parts	5	
The whole centre is about maintaining relationships	4	
STRUCTURAL ENVIRONMENT	5	55
What does he say they're off the reservation	20	90
You wouldn't know half the human race were female	4	6

CENTRE of EXCELLENCE	20	595	22/08/2019 4:32 PM	.
COE COHORTS	8	39	30/08/2019 11:03 PM	.
CoE GROUPS (REFS TO GROUPS)	18	400	25/08/2019 10:33 PM	.
CENTRE ADVISORY GROUP	6	9	22/08/2019 4:32 PM	.
CENTRE EXECUTIVE	7	29	25/08/2019 10:33 PM	.
CENTRE NODE LEADERS	5	17	22/08/2019 4:32 PM	.
CENTRE PROFESSIONAL TEAM	8	24	25/08/2019 10:33 PM	.
CENTRE RESEARCH GROUP	7	28	25/08/2019 10:33 PM	.
CENTRE SCIENCE GROUPS	18	173	22/08/2019 4:32 PM	.
105				
LAUREATES	1	1	14/08/2019 3:24 PM	MEP
PhD_HDR students	8	36	25/08/2019 10:33 PM	.
CENTRE SUB-COMMITTEES	5	12	25/08/2019 10:33 PM	.
WHOLE of CENTRE	8	106	25/08/2019 10:33 PM	.
CoE ROLES (REFS TO INDIVIDUALS)	16	146	20/08/2019 1:19 AM	.
CENTRE DEPUTY DIRECTOR	1	1	27/07/2019 4:08 PM	MEP

CENTRE DIRECTOR	7	56	25/08/2019 10:33 PM	.
CHIEF INVESTIGATOR	13	30	22/08/2019 5:28 PM	.
CHIEF OPERATING OFFICER	8	43	25/08/2019 10:33 PM	.
EXTERNAL FACILITATOR	1	1	30/07/2019 4:01 PM	MEP
LAUREATE	0	0	10/06/2019 2:53 PM	MEP
NODE LEADER	2	11	15/08/2019 7:32 PM	MEP
PhD	0	0	10/06/2019 2:54 PM	MEP
POSTDOC	0	0	10/06/2019 2:55 PM	MEP
WORK PACKAGE LEADER	2	4	25/08/2019 10:33 PM	.

ASSOCIATE / PARTNER INVESTIGATORS 3 322/08/2019 4:32 PM . CENTRE CI GROUP 18 25/08/2019 10:33 PM . FELLOWS_POSTDOCS 7 26 25/08/2019 10:33 PM .

APPENDIX V Integrative Review – Study set analysis

Table V.i   Integrative review framework based on complex systems & views of the actor.

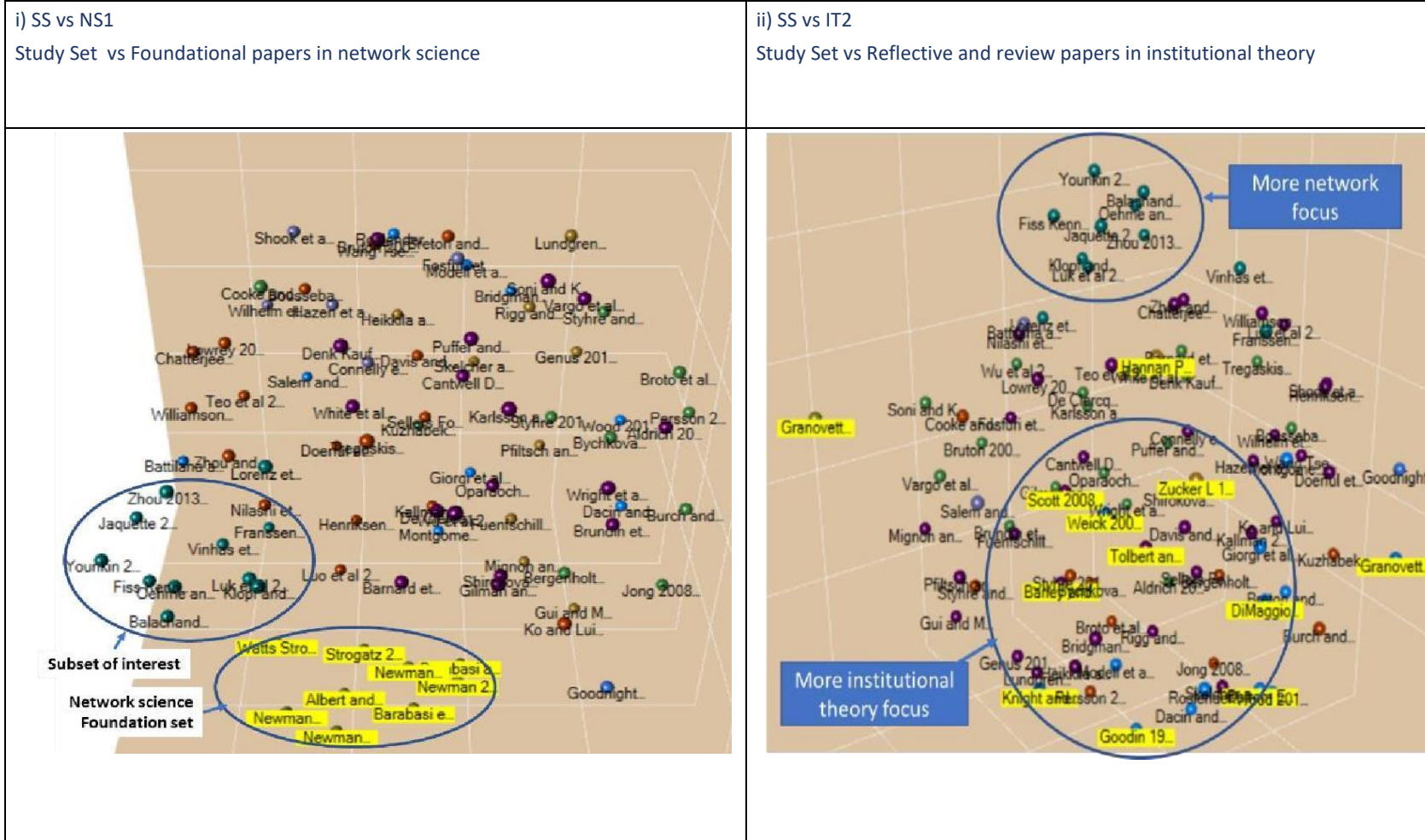| Network Perspective:	Neural Networks / Black Box models	Scale Free Networks	Small World Networks	Dyadic Networks (Weak Ties/ Triads/Triple Helix)	Collectives / Structuration	Collective Rationality / Isomorphism	Institutional Behaviour (Loose Coupling / Sensemaking)
Relation to Sayama's (2015) Complex Systems Classification	**Evolution and Adaptation** Artificial Neural Networks **Systems Theory** Autopoiesis Homeostasis Entropy	**Networks /** Scale Free & Evolving Networks **Patterns** Percolation	**Networks /** Small World Networks Graph Theory	**Networks /** Graph Theory	**Collective Behaviour /** Self-organised criticality **Game Theory** Prisoner's Dilemma Rational Decision Making	**Collective Behaviour?** Synchronisation? **Game Theory?** Bounded rationality? **Pattern Formation?**	**Systems Theory** Loose coupling? Sensemaking
Seminal Paper/s References to key authors	Hannan & Freeman (1977) Wiener (1948) von Bertalanffy (1955) Maturana and Varela (1997)	Albert and Barabási (1999; 2002)	Watts and Strogatz (1999) Newman (2000)	Granovetter (1973; 1985) North (1991)	Ostrom (1990) Giddens (1976) Latour (2005)	DiMaggio and Powell (1983) Tolbert and Zucker (1983)	Weick (1975) Weick (1995)
Conceptual / Theoretical basis	Theory of Evolution Darwin (1859) Theory of Communication. Shannon and Weaver (1949) Information Theory.	Random Graph theory (after Erdős and Rényi, (1959) Preferential Attachment (in relation to Merton (1958)	Graph theory (after Milgram, 1967)	Information Theory (after Rapoport, 1953; 1963) Graph Theory (after Milgram, 1967) Game Theory (after Nash, 1950)	Game Theory (Nash's equilibrium, 1950) Tragedy of the Commons (Hardin, 1968) Structuration (Giddens, 1984)	Rationalist order (Weber, 1952) Structuration (Giddens, 1979) (Granovetter, 1978) (Meyer and Rowan, 1977) (Kanter,1972)	(Loose Coupling after Glassman, 1973) Sensemaking
Reviews / self reflections on seminal work	Pouvreau (2013) Mingers (1995) Ramage and Shipp (2009)	Barábasi (2009; 2012)	Watts (2004)	Granovetter (1985) Rizza (2006) Galiana and Sened (2014) Faundez (2016)	Aligica (2013)	DiMaggio (1995) Greenwood and Meyer (2008) Scott (2014)	Weick, Sutcliffe and Obsfelt (2005) Czarniawska (2005; 2006)

Perspectives of interest in relation to the view of the actor	"…Systems are nets of *relations* which are sustained through *time*. The processes by which they are sustained are the process of *regulation*. The limits within which they can be sustained are the conditions of their *stability*" (Vickers, from Ramage & Shipp, 2009, p 85)	"…In real systems … a series of microscopic events shape network evolution, including the addition or rewiring of new edges or the removal of nodes or edges" (Barabási, 2002, p 79).	"… Changes in the number of partners / connections are evident to the individual whereas transitions to a small world network are not" (Watts & Strogatz, 1999, p 442)	"… [actors] attempts at purposive action are … embedded in concrete, ongoing systems of social relationships" (Granovetter 1985, p 487)	"…when the users of a common-pool resource organize themselves to devise and enforce some of their own basic rules, they tend to manage local resources more sustainably than when rules are externally imposed on them" (Ostrom, 2000, p 148)	"… Organisations may try to change constantly; but, after a certain point in the structuration of an organisational field, the aggregate effect of individual change is to lessen the diversity within the field" (DiMaggio & Powell, 1983, pp 148-149)	"…Sensemaking starts with chaos … the ongoing potential for "clusters of things that go wrong"— part of an almost infinite stream of events and inputs that surround any organizational actor…" (Weick, Sutcliffe and Obsfelt, 2005, p 411)

Table V.ii Integrative review framework based on network analysis approach

Network Perspective:	Neural Networks / Blackbox models	Scale Free Networks	Small World Networks	Dyadic Networks (Weak Ties/ Triads/Triple Helix)	Collectives / Structuration
References to key authors > 2/ # refs to authors in set of 79 papers	**von Bertalanffy (1)**	*No* papers refer to **Albert / Barabási**	**Watts (2)**	**Granovetter (14)**	**Ostrom (4) Latour (3) Giddens (3)**
Example Methodologies applied	Mathematical modelling; conceptual developments	Big Data analytics; Mathematical simulations; Network Patterns; Topological mapping	Mathematical simulations; Network order of randomness	Socio-metrics; Social Network analysis; Historic analysis (North)	Theoretical approach; Qualitative; real world eg Interviews with economic analytical view.
Legend: Search Term frequency: # of papers using reference – (#) of times terms used (>2 per paper) **Author/s** *(publication year) # times term appears in paper*	**Complexity 14 (*102*)** (Nilashi et al, 2016) *25* (Teo et al, 2003) *23* (Lorenz et al 2018) *13* **Complex Systems** (Nilashi et al., 2016)*1* **Ecosystem (*3*)** (Vargo et al, 2015) *57* (Bychkova, 2016) *7* (Soni & Krishnan, 2014) *6*	**Topology 1 (*18*)** (Pflitsch & Radinger-Peer, 2018) *18* **Clusters 7 (*54*)** (Balachandran & Hernandez, 2018) *16* (White et al, 2016) *10* (Franssen & Kuipers, 2013) *8* (Bruton et al, 2009) *7* **Hubs 1 (*3*)** (Lundgren & Westlund, 2017) *3*	**Nodes 13 (*26*)** (Henriksen & Seabrooke, 2016) *7* (Fiss et al, 2012) *5* **Centrality 16 (*173*)** (Luo et al, 2009) *48* (Oehme & Bort, 2015) *39* (Fiss et al., 2012) *31* (Henriksen & Seabrooke, 2016) *29*	**Weak Ties 4 (*47*)** (Bergenholtz & Bjerregaard, 2014) *25* (Lowrey, 2011) *21* (Shirokova & McDougallCovin, 2012) *7* **Triad 1 (*43*)** (Balachandran & Hernandez, 2018) *43* **Triple Helix 2 (*74*)** (Brundin et al, 2008) *71* (Pflitsch & Radinger-Peer, 2018) *3* **Embeddedness 15 (*207*)** (Klopf & Nell, 2017) *116* (Sa Vinhas et al, 2012) *17*	**Collectives 23 (*192*)** (Heikkila & Isett, 2004) *39* (Giorgi et al, 2017) *37* (Mignon & Bergek, 2016) *14* **Norms 43 (*280*)** Wang et al (2014) *119* (Heikkila & Isett, 2004) *31* (Bergenholtz & Bjerregaard, 2014) *21* (Castán Broto et al, 2009) *14* **Actor networks 3 (*28*)** (Modell et al., 2017) *17* (Hazen et al, 2016) *8*

APPENDIX VI Integrative Review - Cluster analysis visualisation

Figure VI.1   Cluster analysis of study set papers compared with institutional and network science sets using Pearson's Coefficient in NVIVO12.

i) SS vs NS1 Study Set vs Foundational papers in network science	ii) SS vs IT2 Study Set vs Reflective and review papers in institutional theory

Appendix VII: Comparative network vocabulary: network science, mathematical sociology and institutional theory

KEY to REFERENCE SOURCES IN TABLE

Barabási et al (2002)	DiMaggio and Powell (1983)	Greenwood and Hinings (2012)	Watts (2004)	Bonacich (2008)	Newman (2004)

Phenomenon / Mathematical term	Network Science	Network theory / descriptive	Mathematical sociology	Sociological / Descriptive
Scope				
Universality	recent empirical network findings suggest that **care is required when claiming universal features of networks**, particularly when the claims in question extend to the collective dynamics of networked systems p. 256			Exploring how organizations are connected and how those connections enable and frame the institutionalization of ideas and practices became a defining feature of subsequent institutional work.
Scale				Organisations in aggregate constitute **Institutional life** In In Greenwood and Hinings (Warren, Rose and Gergunder, 1974)
Cumulative network, System	the structure of a network can have dramatic implications for the **collective dynamics of a system**, whose connectivity the network represents. In particular, they claimed that large changes in dynamical behavior could be driven by even subtle modifications to the network structure - modifications that may be imperceptible to actors with only **local knowledge of the network p. 246**			**Organisation Fields** Instead of encircling competing firms as "populations" (Hannan & Freeman, 1977), the imagery is of **organizations linked in a network of relationships to others of similar and dissimilar forms**. p.261

Phenomenon / Mathematical term	Network Science	Network theory / descriptive	Mathematical sociology	Sociological / Descriptive

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				Multi-organizational field (after Curtis and Zurcher, 1973) was explicitly chosen as [the] level of analysis because it "directs our attention to the totality of relevant actors" p.261 Industrial systems (Hirsch, 1972) p.261
Ecosystem				**Ecosystem / Institutional field**
Network Structure				
Shape / Form / Graph = mathematical structure	Topology / Graph (overall description of network)	Network topology		**Organisational form** is determined by the distribution of resources in the environment p.155
Lattice / Substrate / Ordered network	the term "lattice" is used in the physicist's sense of a *crystal lattice* (roughly, a low dimensional grid), not the mathematician's sense of a partial ordering on a set of elements (Watt, 2004, p.244)	Parameterized models of **locally ordered** but otherwise random networks, for example, had been the object of social network analysts' attention for decades, at first according to Rapoport's notion of **random-biased nets** (Rapoport 1951, 1957), (Watts, 2004, p. 246)		**Diffusion structure** Fields that have stable and broadly acknowledged centers, peripheries, and **status orders will be more homogeneous both because the diffusion structure for new models and norms is more routine and because the level of interaction among organizations in the field is higher**
Connector / Vertex (*i*)	Node (*i*)			
Connection / Edge (*k*)	Links (*k*) Also referred to as Edges	Ties / Local Bridges / Shortcuts Granovetter (1973), following Rapoport, introduced "strong ties" which could be construed as arising from local ordering principles like **homophily** (Lazarsfeld & Merton 1954) & **triadic closure** (Rapoport 1953a), "weak" ties are related to occasional random contacts, which Granovetter called **local**		Connectedness / Ties **existence of transactions tying organizations to one another – [such as]** or informal

Phenomenon / Mathematical term	Network Science	Network theory / descriptive	Mathematical sociology	Sociological / Descriptive
		bridges, but which are clearly analogous to Watts & Strogatz's **shortcuts**. (Watts, 2004, p.246)		**organizational-level ties** like personnel flows p. 148

Internodal Path / Distance (*l*)	The ability of two nodes, *i* and *j*, to communicate with each other depends on the length of the shortest path, *lij* , between them.			
Average distance / separation / Interconnectedness (*d*)	The average of *lij* over all pairs of nodes [are] denoted by *d* = (*lij*), and we call it the **average separation of the network**, **characterizing the networks interconnectedness**.	L = the average shortest path length which is a global measure of separation p. 244		**Inter-organisational networks** (Laumann, Galaskiewicz and Marsden, 1978) p. 261
Degree distribution *P(k)*	*P(k)*: The probability that a randomly selected node in a network has *k* links.			
Network Behaviour				
Clustering coefficient	Where N_i = the number of links that connect the selected k_i nodes to each other, the clustering coefficient for node *i* is $C_i = 2N_i = k_i(k_i - 1)$.	Example: in a co-authorship network how much is one node's collaborators willing to collaborate with each other = probability that two collaborators wrote the paper together.	"Clustering," contains unfamiliar (to sociologists) approaches to block modeling (Bonacic, 2008, p. 427)	
Clustering characteristics	Clustering – the characteristic of real networks that deviate from a completely random ER model.	Clustering coefficient of a network is a measure of local density (p. 245)		Note that **organisations are connected via other links even if they themselves are not connected** "…here the key structure is the *role* or *block*." p.148

Phenomenon / Mathematical term	Network Science	Network theory / descriptive	Mathematical sociology	Sociological / Descriptive
Network Classes				

Term	Network Science	Network theory / descriptive	Mathematical sociology	Sociological / Descriptive
Random network	$P(k)$ - the probability that a randomly selected node has k links – shows exponential decay. Erdős-Renyi model	Rapoport (1953) was concerned with the effect of **socio-structural biases in otherwise random networks** on the spread of information or infectious disease. Watts, 2004,		
Clique	Clique – if fully connected $k(k_i - 1) = 2$	"locally dense groups" of vertices (nodes) in a network - maximal completely connected subsets of vertices. p.427		**[A clique is defined as] - A set of organizations that are strongly connected to one another** and only weakly connected to other organizations p. 148
Hubs = Authority	Kleinberg refers to a vertex that is pointed to by highly ranked vertices as an **authority** - it is likely to contain relevant information. Such a vertex gets a weight x_i that is large … and is referred to as a **hub**; while it may not contain directly relevant information, it can tell you where to find such information. (Newman, 2004, p. 44)	[skewed distribution in scale-free networks] a small fraction of **hubs** are many times better connected than average. (p. 250) – also see preferential attachment		The designation of a few large firms in an industry as key bargaining agents in union-management negotiations may make these **central firms** pivotal in other respects as well (p. 153)
Small World Network	$P(k)$ - the probability that a randomly selected node has k links – shows **exponential decay** + even large networks have small separation **Watts-Strogatz model**	Real-world networks are neither completely ordered nor completely random, but rather exhibit important properties of both. In Watts&Strogatz's specific example, "order" was represented by a uniform one-dimensional lattice = 1, where each node was connected to its k nearest	**Unfortunately, the Watts-Strogatz model suffers from some serious problems that render it unsuitable as a model of social networks.**	

Phenomenon / Mathematical term	Network Science	Network theory / descriptive	Mathematical sociology	Sociological / Descriptive
		neighbors on the lattice, and "randomness" was characterized by a tunable parameter p that specified the fraction of randomly rewired links		

Phenomenon / Mathematical term	Network Science	Network theory / descriptive	Mathematical sociology	Sociological / Descriptive
Generalised SmallWorld Network. **Kleinberg model**		Kleinberg (2000 a,b) … observed that the small-world experiments of Milgram and others (Korte & Milgram 1970, Milgram 1967, Travers & Milgram 1969) demonstrated not only that short paths existed between randomly chosen individuals in a large population, but also **that the individuals in question could locate these paths using only their local information about the network.** Social networks, in other words, are not only small; they are also searchable. (Watts, 2004, 247).		
Scale-free Network	*P(k)* - the probability that a randomly selected node has *k* links – shows a **power law tail.**	a scale-free network is determined almost entirely by the small fraction of highly connected **hubs** that occupy the tail of the degree distribution (Watts, 2004, p.262)		
Bipartite / Affiliation Networks		(For example) In such a model **the basic unit is a paper that** involves several **"old" and "new" authors**. In such a framework one can simultaneously study the evolution of the co-authorship network (in which nodes are scientists linked by joint publications) and the publication network (in which nodes are papers, linked by joint authors).		
Ultrarobust network	Ultrarobustness [means] … organizational networks must exhibit non-hierarchical ties that extend across all scales of the underlying hierarchy— a quantitative result			

Phenomenon / Mathematical term	Network Science	Network theory / descriptive	Mathematical sociology	Sociological / Descriptive
	that stands in qualitative agreement with a longstanding body of work in organizational sociology (Burns & Stalker 1961, Granovetter 1985, Lawrence & Lorsch 1967), and is also consistent with recent accounts of firms surviving major disasters (Kelly & Stark 2002, Nishiguchi & Beaudet 2000).			
Community Networks				Users of a resource Amalgamative interactions
Network Dynamics				
	Continuum Theory Considers the rate at which new nodes join the network. $k_i(t)$ is the number of links node i has at time t; by $T(t)$ and $N(t)$ the so that the average number of links of node i at time t, respectively is k = T(t)N(t) This Continuum equation assumes new links join the system at a constant rate β. Eg consider that new researchers join the in the field at a constant rate, leading to $N(t) = β \, t$			
	Predicts the connectivity distribution over time.			

Phenomenon / Mathematical term	Network Science	Network theory / descriptive	Mathematical sociology	Sociological / Descriptive
	The evolution of the network relates to the change in the number of links to node over time dk/dt which is a product of the number of links from new nodes and the increase in number of links with existing nodes in 'the system'.			
Triadic closure	**noted as related to random biased nets** (Rapoport,1953) in Watts, 2004, 246.	Models of network transivity make use of 'triadic closure' - in these models, edges are added to the network preferentially between pairs of vertices that have another third vertex as a common neighbour. In other words, edges are added [to complete] triangles. Newman (2004, p. 30)	[Part of text by Brandes and Erlebach (2005)] is focused on the narrow (for sociologists) problem of finding out if two networks are isomorphic.	**Triadic, Dryadic** **Structural equivalence** (after White, 1976) two organizations are structurally equivalent if they have ties of the same kind to the same set of other organizations p. 148
Network phenomena				
Preferential attachment	The Erdős Number in mathematics The tightly interconnected nature of the scientific community is reflected by the conjecture that all publishing mathematicians, as well as many physicists and economists have rather small Erdős numbers		Along the way some new and unfamiliar measures are introduced: stress centrality, transversal sets centrality, random walk closeness centrality, random walk betweenness centrality p. 427 The Matthew Effect /	[Organisational] centrality is reinforced as upwardly mobile managers and staff seek to secure positions in these **central organizations** in order to further their own careers. P. 153
Node trimming / Percolation		that the connectivity of a scale-free network is determined almost entirely by the small fraction of highly		

		connected hubs that occupy the tail of the degree distribution. Because random failures are relatively unlikely to affect the hubs, the only nodes that are likely to become disconnected are those that fail. But when the hubs are deliberately targeted, each individual failure has the potential to impact the connectivity of the entire network.		
Order and Randomness	**Small World Networks** When $p = 0$ (completely ordered), the network is "large" [$L(0) \sim N/2k$] and "highly clustered" [$C(0) \sim 3/4$], and when $p = 1$ (completely random), it is "small" [$L(1) \sim \ln(N)/\ln(k)$] and "poorly clustered" [$C(1) \sim k/N$], suggesting that path lengths are short only when clustering is low.	In Watts & Strogatz's Small World model, "order" was represented by a uniform one-dimensional lattice, 1 where each node was connected to its k nearest neighbours on the lattice, and "randomness" was characterized by a tunable parameter p that specified the fraction of randomly rewired links. (Watts, 2004, p.244)		

Paradoxical Network Behaviour				
Paradoxical cases		that scale-free random networks of the kind generated through growth and preferential attachment exhibit much greater resilience to random failures than Bernoulli random graphs, where they defined resilience as the size of the largest connected component [hub] remaining after a certain fraction of nodes in the network had been removed. When nodes were removed preferentially, however, in order from highest to lowest degree, the opposite result pertained.	A focus on the narrow (for sociologists) problem of finding out if two networks are isomorphic. p.427	Effects of uncertainty and ambiguity p. 156 Somewhat counterintuitively, abrupt increases in uncertainty and ambiguity should, after brief periods of ideologically motivated experimentation, lead to rapid isomorphic change. (after Granovetter)

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