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TRENDS, TROPES AND POSITIONING IN THE UNIVERSITY RESEARCH SUB-SYSTEM IN EMERGING KNOWLEDGE ECONOMIES: A THEORY OF RESEARCH ENTANGLEMENT

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A thesis submitted to the Faculty of Commerce, Law and Management,
University of the Witwatersrand, Johannesburg,
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ABSTRACT

Universities in 21st century emerging knowledge economies seek to build a culture and practice of research activeness and intensiveness. How do university research sub-systems position universities to push through conditions of adversity to realise research activeness and intensiveness?

Based on data collected from an exploratory study of selected research active universities in India and four case studies from a single research active university in South Africa, the research finds that university research sub-systems, operating in emerging knowledge economies, are engaged in quantum research games. Research complexity and adversity; uncertainty with respect to the outcomes and impact of research; and contestation with respect to resources, values and value; renders the university research game a quantum game, leading to the research entanglement of scientist-researchers.

Epistemologically located in social constructionism and using grounded theory analytical methodology, the theory of positioning universities for research activeness and intensiveness through research entanglement identifies four trends of entanglement. Research actors who operate in a habitual state of heightened entanglement are able to push through adversity.

It is theorised that the position of leaning towards heightened research entanglement creates an advantage for universities towards achieving greater research activeness and intensiveness. Where the position of leaning away from entanglement is dominant, this may create institutional stasis and an inability to advance the institution towards greater research effort.

DECLARATION

I, Lucienne Ann Abrahams, hereby declare that this thesis is my own, unaided work. It is submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other university.

Signature:

Date:

DEDICATION

Patrick – for collaborative writing about Aristotelian concepts of values and value. and conversations about Schrödinger's cat.

Ashlee – for accepting years of writing and writing and writing.

Ivan – for being a teacher in life and beyond.

Julia – for introducing music as a companion to thought.

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GLOSSARY OF TERMS

The glossary utilises the author's own explanation of particular terms.

collaborative working space	*shared space where people work independently or collaboratively utilising common space and resources*
commercialisation of knowledge	*the processes leading to the translation of research or technology into commercial production and availability in markets for goods or services*
entrepreneurial science	*the practice of science with the intention of achieving commercial rewards*
intellectual property rights	*forms of ownership of knowledge established in legislation*
knowledge economy	*an economy in which scientific, technological or research-based knowledge is a significant contributing factor in economic development in any or all economic sectors*
open access publishing	*forms of scholarly publishing where readers have open access to the publication from the Internet at no cost other than the cost of Internet access and where the content may be freely utilised subject only to attribution and sharing, for either commercial or non-commercial use depending on the terms of the license*
positioning	*the art of enabling desired outcomes through lived strategy* (with acknowledgement to the writings of Sun Tzu)
quantum research games	*multiple, complex games played continuously among research actors, and among research-oriented institutions in order to achieve complex objectives which do not rely on simple games*
research activeness	*the widespread practice of postgraduate study, academic research and scholarly publishing at the institution*

research actors	*academics, scientists, research managers, industry research partners, government and international scientific research funders, all parties participating in the practice of university-based research*
research entanglement	*actor and institutional immersion in complex research activities or quantum research games in circumstances where the outcome of these games and value of participation is unpredictable*
research institutions	*universities and other institutional research partners*
research intensiveness	*the production of high volumes of research-based knowledge per academic staff member and high rate of conversion of knowledge to explicit social or economic value*
research-oriented resources	*financial, human, land, buildings, infrastructure and institutional structures servicing university-based research*
socialisation of knowledge	*the processes of diffusing knowledge into society through teaching, lectures, publishing and other mediums of public and private dissemination*
technology transfer	*the process of transforming research knowledge into technological artefacts*
trends	*typical direction or nature of change in behaviours or occurrences*
tropes	*metaphors applicable to explain categories or themes in data*
research-oriented values	*the ecosystem of values impacting on the university that influences research production, research activeness and research intensiveness*
research value	*the intellectual, social or economic value produced from university based research*

LIST OF ABBREVIATIONS

AICTE	All India Council for Technical Education
AIDC	Automotive Industry Development Centre
ASSAf	Academy of Science of South Africa
BRICS	Brazil, Russia, India, China, South Africa
CHET	Centre for Higher Education Transformation
CIPRO	Companies and Intellectual Property Rights Office
CMMI	Capability Maturity Model Integration
CSIR	Council for Scientific and Industrial Research
DHET	Department of Higher Education and Training
DOAJ	Directory of Open Access Journals
DST	Department of Science and Technology
DVC	Deputy Vice Chancellor
GDP	Gross domestic product
GERD	Gross domestic expenditure on research and development
GoI	Government of India
HDSS	Health and demographic surveillance system
HEMIS	Higher education management information system
HESA	Higher Education South Africa
ICT	Information and communications technologies
INR	Indian rupees
IP	Intellectual property
IPR	Intellectual property rights
IPR-PFRD	Intellectual Property Rights from Publicly Financed Research and Development
ISI	Institute for Scientific Information
JCSE	Joburg Centre for Software Engineering

NACI	National Advisory Council on Innovation
NGO	Non-governmental organisation
NIPMO	National Intellectual Property Management Office
NREN	National research and education network
NRF	National Research Foundation
NSI	National system of innovation
OA	Open access
OECD	Organisation for Economic Cooperation and Development
PLoS	Public Library of Science
PoP	Point of presence
R&D	Research and development
RSA	Republic of South Africa
RREN	Regional research and education network
SAEON	South African Environmental Observation Network
SALT	South African Large Telescope
SANBI	South African National Botanical Institute
SANParks	South African National Parks
SANReN	South African National Research and Education Network
SARChI	South African Research Chairs Initiative
SAUVCA	South African University Vice-Chancellors Association
SAVCA	South African Venture Capital Association
SCI	Science Citation Index
SET	Science, engineering and technology
SETI	Science, engineering and technology institutions
SKA	Square Kilometre Array (radio-telescope)
SITA	State Information Technology Agency
SPARC	Scholarly Publishing and Academic Resources Coalition
TIA	Technology Innovation Agency

TTO	Technology transfer office
UCT	University of Cape Town
US	United States (of America)
VC	Vice Chancellor
WCE	Wits Commercial Enterprise
Wits SPARC	Wits Strategic Planning and Allocation of Resources Committee
ZAR	South African rand

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Chapter 1 Context and challenges for university research and innovation in emerging knowledge economies: Drawing on India and South Africa

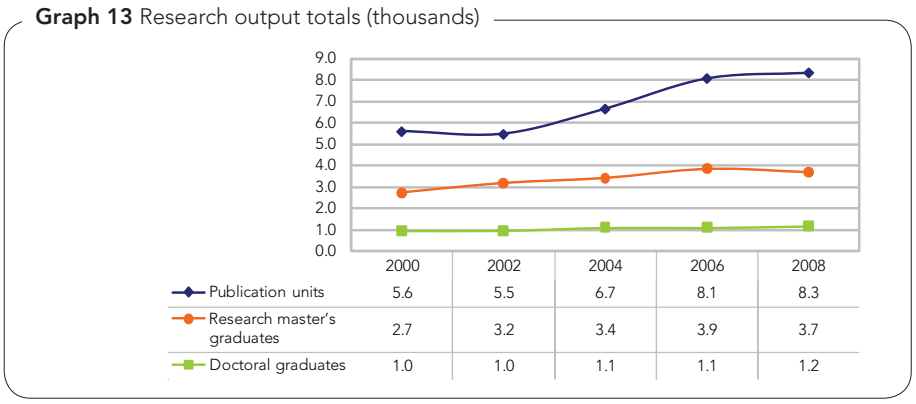
1.1 Preface

Universities in South Africa and other emerging economies operate within the context of a global transition from industrial-services economies to knowledge-based economies, needing to make adaptations to function effectively in the changed landscape. They also function as part of the broader research and innovation system, with respect to their knowledge-based activities including human capital production and research and innovation production. Amongst other discussions of the university from a knowledge economy perspective, Mohrman, Ma and Baker (2008) discuss the "emerging global model" of the "research university in transition", noting eight characteristics. However, they cover only a few of the issues pertinent to the research university's transition. In which ways do academic researchers and scientists engage in the creation of research production and thereby also in the creation of the future research and innovation system? What forms of creative thinking and doing are brought to bear upon the formation of the next generation research university? How is leadership given to reshaping of the knowledge paradigm? In which ways do the resource environments of research universities relate to the production of knowledge? These and other questions require attention from researchers in emerging economies and are relevant to this thesis. This study investigates positioning strategy in the university research sub-systems of research-based universities in two countries, namely India and South Africa, for the reasons advanced below.

1.2 Building the knowledge base with respect to research outputs from the university system

Amongst the many outputs from the South African university system, research outputs are increasing in volume and in value to economy and society. However, there is only limited understanding of the extent and nature of these outputs, and the conditions under which they are produced, some of the few relevant studies being that of Bunting, Sheppard, Cloete and Belding (2010), see Figure 1 below; Cloete, Bailey, Pillay, Bunting and Maassen (2011); and Bunting and Cloete (2012).

Figure 1.1 DHET-funded research outputs



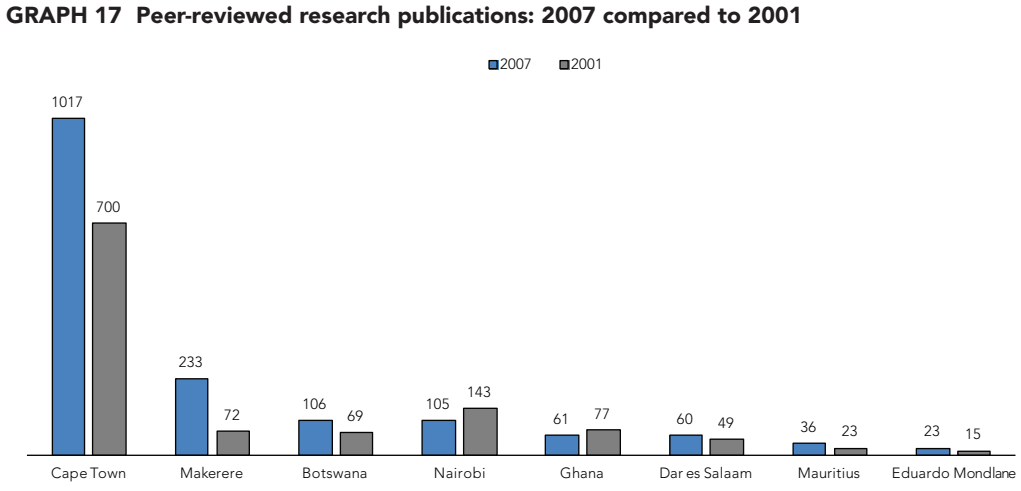
Source: Bunting, Sheppard, Cloete & Belding, 2010, p. 19

The data for research outputs in Figure 1 includes research published in peer-reviewed journals and books (publication units) and research components of postgraduate degrees, but does not include research output in the form of novel discoveries and inventions, prototypes, patents and technology licences, technology transfer activities, technology or other forms of intellectual property that are potentially commercialisable or, in a few instances, already commercialised. Nevertheless, for the component of research output reported in the Bunting et al. (2010) study, it is noted that research publication units

increased by an average 5% per annum over the study period (Bunting, et al., 2010, p.22) for South African universities.

In a study of eight African universities, Bunting and Cloete (2011, p.38) observed the limited increase in peer-reviewed publications over the period 2001 to 2007 (Figure 1.2) and that universities on the African continent typically did not have a "major involvement" in research (Figure 1.3), while only one, the University of Cape Town, had a "substantial involvement in research".

Figure 1.2 Comparative number of peer-reviewed research publications



Source: Bunting & Cloete, 2011, p. 30

The data presented in Figure 1.2 and Figure 1.3 for "level of involvement" in research suggests that many universities in South Africa and on the African continent may be research active, but are generally not engaged in research-intensive knowledge production. The level of involvement in research may, however, be considered by examination of other forms of research production than peer reviewed publications, including novel discoveries and inventions, pre-competitive research production, or licensing intellectual property, as well as

analysis of research value understood through publication and patent citations, and the utilisation of university research or patents by the private sector.

Figure 1.3 Reflection on research activeness ("level of involvement in research")

TABLE 13 Research profile: peer reviewed publications

	Ratio of peer-reviewed publications to FTE academic staff: 3 year averages	
		Peer-reviewed publications profile
Cape Town	1.1	Substantial
Botswana	0.1	Some
Dar es Salaam	0.1	Some
Ghana	0.1	Some
Makerere	0.1	Some
Mauritius	0.1	Some
Nairobi	0.1	Some
Eduardo Mondlane	0.0	None

Major: more than 2
Substantial: between 1 and 2
Some: between 0.1 and 1
None: less than 0.1

Source: Bunting & Cloete, 2011, p. 37

More importantly, given the low levels of research publication and broader research production in the South African and other African country university research sub-systems, questions arise about the nature of the research production undertaking, including (i) the process of becoming research active and (ii) transitioning from research activeness to research intensiveness. Research activeness is understood here to include reference to medium or weak graduation rates in science, engineering and technology (SET); medium or weak levels of doctoral graduations; medium or weak ratios of research publications per academic (Bunting & Cloete, 2011, p. 19) applicable in many universities, but limited if any engagement in other forms of research and innovation production. Research intensiveness is understood here to include reference to high graduation rates in SET fields, high levels of doctoral graduations, the ratio of peer-reviewed publications to full-time equivalents of academic staff should be

2.0 or higher (Bunting & Cloete, p. 19; p. 37), high rates of invention and patenting, high levels of publication and patent citation, high quality patents (Henderson, Jaffe & Trajtenberg, 1998), applicable in reasonably few universities compared to the global total. Research activeness and research intensiveness are dependent on building the research institutional and research process sub-system of the university.

The rate of global knowledge production increased rapidly in the final quarter of the twentieth century and the first decade of the twenty-first century, speeded up by the relative ease of accessibility of such knowledge through extended global institutional networks and the Internet, through increases in funding for research and development (R&D), through the "rise of the research agenda" in the context of the marketization of higher education (Palfreyman & Tapper, 2014), as well as through heightened demand for knowledge services and environmental sustainability (Castells, 1996; Melody, 2002; Perez, 2004). As local and global knowledge networks emerged and the mobility of people and ideas in virtual space-time grew in the early 21st century, this set the tone for an economic paradigm in which the pace of innovation and global communication intensified beyond the scale of any previous historical era, thereby establishing knowledge and ICT networks as driving forces for a new economy (Melody, 2002).

In this environment, institutions and economic sectors experience high impact change – production and supply chain efficiencies for manufacturing are gained through business process innovation and the Internet of Things, commerce and trade are enabled through ICT applications, governments introduce electronic government services, demand grows for increasingly rapid creation and sharing of new knowledge and commercialisation of technology, in order to promote business and country competitiveness. This heightened economic activity, as compared to the previous 'industrial age', places greater demands on the builders of human capital – namely the schools, universities and other

knowledge-based institutions – to reposition themselves to become ever more productive both in graduate numbers and in the quality of knowledge and research produced (Melody, 2002; Olsen, 2005; Olsen, 2007; Marginson, 2010; Pinheiro, Geschwind & Aarrevaara, 2014). How are academics and the university research sub-system responding to these broader changes? What approaches exist to effective positioning of university-based research and the university research sub-system in developing countries?

In the 21st century, South Africa and India have moved forward, out of centuries of colonialist rule affected by class differentials and social disparities, emerging as knowledge-based economies. Their challenges of poverty and development require the knowledge services of large numbers of scientists, professionals and social analysts, and hence greater access to and quality of research output. Like other emerging economies, they are integrating into the global economy, seeking the benefits of such integration, which are uncertain. India and South Africa also have dissimilarities, as India has a population several orders of magnitude larger than South Africa (approximately 23 times as large by population); India is located in the South East Asia region, which is experiencing relatively higher economic growth than the Southern African region; and the complexity of India's economy, university and research systems does not offer a simple comparison for South Africa. Nevertheless, as these two countries have been engaged in processes of global integration and formation of national systems for research and innovation for at least two decades (Abrahams & Pogue, 2012; Ratchford & Blanpied, 2008; Segal, 2008), it is appropriate to study trends in research production at universities in India and South Africa, as lenses through which to contemplate the trends and positioning of universities in emerging economies.

Universities may be conceived of as complex and composite institutions that are integral components of the national systems of innovation (NSI) and major generators of human resource capacity for labour markets including those of

academic research. Ratchford and Blanpied (2008, pp.219 & 222), in their extensive review of the history of science and higher education in China, India and the United States, have argued that the transition towards research-based innovation in higher education has occurred in China and India from 2003, as particular higher education institutions were included in broader innovation system planning. Segal (2008) has drawn attention to the interconnectedness of the innovation systems of China, India and the United States, noting the propensity for the benefits of such globalisation of science and innovation to extend to minorities in China and India.

Universities in smaller systems, such as South Africa, have participated in global science, but are not as strongly tied in to the global innovation system as in India and China. In seeking greater global integration, a particular issue for universities has been the commercialisation of intellectual property in order to utilise research output as a basis for building new revenue streams for the university and for participating in global research, or as the basis for industry knowledge partnerships. Commercialisation agencies have been created at Wits, Stellenbosch University and UCT to seek out revenue-generating opportunities, but they have confronted a major learning process as they sought to understand and appropriately position the work of the participating institutions.

1.3 Thesis introduction

This thesis is an attempt to shed light on and understand the dynamics of universities, with respect to what Clark (1983) calls their research sub-systems, specifically universities in formative knowledge economies, in regions of the world that were less favoured in the twentieth century. The use of research "sub-system" in this thesis refers to a wide range of activities, including but not limited to designing research projects, engaging in research and innovation production, scholarly publication and communication. The thesis explores *how* universities are positioning themselves, their inner trajectories of being connected

to knowledge production, dissemination and engagement with knowledge communities. Its rationale lies within that part of the domain of institutional change theory that is about strategic positioning, connected with the objective of increasing research activeness and research intensiveness. In order to conduct this investigation, the scope of the study was limited to a high level review of a few research-performing universities in India, and a set of in-depth case studies at a single research-performing university in South Africa. The motivation for this selection is that there is a greater degree of relevance to be attained by studying those institutions that are more similar than dissimilar.

The main influences on the thinking and analysis presented in this grounded theory case study arise from observation, immersion in the subject matter and data analysis, not from existing literature. While the approach for this study has ontological roots, as I wished to understand the coming into being of particular research behaviour, it is noted that Clark (1972; 1998a) adopted this approach for his studies on the organisational saga of universities and on pathways of transformation in universities. At the completion stage, this research was only able to provide a limited set of perspectives on strategic positioning in the research sub-system. The study design and data collection process led to a particular "sidetrack" of enquiry (Cryer, 2006), namely an identification and theorisation of particular practices with respect to research production, research activeness and research intensiveness.

The following section sets out the research aim, problem statement, purpose statement and research questions. A more detailed background to the research follows, which explains the rationale for the problem statement and research questions.

1.4 Research aim

The aim of the research was to bring some insight to a wide and chaotic debate on the transitions occurring in universities in South Africa, with respect to the trend towards research activeness and intensiveness. The debate was perceived as chaotic because there has been no systematic approach to holding the ideas of "redress" in the same conversation as ideas about "research-intensiveness", even under conditions where these may be mutually supporting ideas. As the research progressed, it sought to discover why the push for research intensiveness grew stronger despite considerable adversity experienced by research actors and the university research sub-system.

The aim of the research therefore was to understand the nature of the challenges involved in becoming and remaining knowledge-intensive universities, since, based on the above overview, an assumption that universities are by definition knowledge-rich does not hold true. The study aimed to seek beyond the findings of national policy documents to understand the dynamics of university transitions at the institutional, sub-institutional and researcher levels. Understanding innovation system formation in universities was regarded as crucial to understanding the strengths, weaknesses and opportunities that may exist with respect to future knowledge-intensive research activity.

1.5 Research problem statement

In the last thirty years, many universities across the world have proceeded to reposition themselves with respect to the emergence of a socio-economic paradigm that focuses on universities as institutions driving high degrees of knowledge and technology intensity through research and innovation and "entrepreneurial science" (Clark, 1998a, 2001; Etzkowitz, 1998; Etzkowitz, 2002; Perez, 1992; Shattock, 2009; Pinheiro & Stensaker, 2013). This has resulted from the knowledge capacity that resides in universities providing the basis for innovation and development in economies and societies, leading to the formation

of what is now generally referred to as a knowledge economy (Marginson, 2010; Maassen & Cloete, 2006; Temple, 2011; Varga, 2009).

Emerging economies have sought to be globally competitive and to foster socio-economic development to reduce poverty, thus universities are challenged to undergo a transition from the historical focus on graduate programmes and limited research, to becoming powerful research-based institutions participating in knowledge production needed to fuel scientific and technological development for a growing economy. Furthermore, the national innovation system, within which universities reside, has required renewal.

Large research active universities have been engaged in repositioning their institutions in ways that would enable them to advance their research intensiveness. The assumption that leading universities in emerging economies would move smartly to achieve this repositioning, due to high development demands, is not borne out by reality. There are hurdles to such movement and it is not obvious how the university research sub-system responds to them. Alternatively, the phenomenon of positioning may not be easy to decode, due to the delay between the input stage of research activeness or research intensiveness and the outcome stage of such research-based activity. While many trends in research active universities have been charted and published, these do not present the full range of trends that occur, or strategic positioning approaches that could be relevant to research practice in universities in emerging economies.

Furthermore, there has been a keenness in the university sector to follow trends from the developed world including attention to concepts such as the multiple helices of university-industry-government-community-other research relations, possibly because these concepts are well documented (Ery Supriyadi, 2012). However, there is a gap in knowledge with respect to charting an understanding of the themes, trends and approaches to university positioning in emerging

economies that lies beyond the current discourse, notably in the struggles to increase the research orientation of universities.

Hence, the research problem for investigation pertains to the current gap in knowledge, with respect to the strategic approaches within university research sub-systems, for increasing knowledge-intensity in formative knowledge economies, such as those of South Africa and India.

1.6 Purpose statement

The purpose of this study is to discover any paradigm shifts that may be evolving pertaining to universities in emerging knowledge economies, predominantly with respect to perspectives from research active universities in India and South Africa. This research aims at finding additional insights to those already found, as set out in the literature review. For this purpose, the research uses a grounded theory research design for data collection, analysis and theory building, incorporating case study methods for data collection. This research design enabled the researcher to narrow down the study from the initial broad perspective on the university to specific insights on what is involved in building research activeness and research intensiveness.

For the purposes of this study, such insights were sought with respect to a defined scope, including (a) trends in research activity and in the academic research paradigm, (b) examination of the knowledge generation approaches and capacities in university research entities, (c) examination of 21st century knowledge partnerships. Cross-cutting to these themes, (d) new research modalities generated by Internet access were explored. The study commenced with a broad exploration of the South African case study university, leading to a deeper review of a limited number of activities and events in selected research-performing universities in India and selected events and cross-disciplinary initiatives at the University of the Witwatersrand, South Africa, treating these as

case studies in large research active universities. This selection of activities and events emerged from the design of the study, based on ideas generated in the exploration phase of the research, explained in Chapter 3. In the context of a transition from a services-based economy to a knowledge-intensive and innovation-focused economy, this multiple case study utilises document analysis, semi-structured interviews and participant observation to explore and map selected knowledge economy-oriented activities of academics and administrators in university research entities and contexts. Following a grounded theory approach, inductive and counter-inductive reasoning are used (i) to elucidate specific practices by which a few research-active universities are positioning themselves in the context of a large-scale socio-economic transition and (ii) to discuss how the insights acquired may be more generally applicable to research-active universities in emerging knowledge economies. Analysis of the data enabled the researcher to formulate a theory about the positioning of universities for greater research activeness and research intensiveness in an emerging knowledge-based economy. This theory building is not offered in the mode of "grand theory", rather it is a contribution to charting the many contours in university research evolution in emerging economies in the early 21st century.

1.7 Research question

The main research question was reformulated and rephrased several times as the research advanced beyond the early exploratory phase:

> How do university research sub-systems position universities to push through conditions of adversity to realise research activeness and intensiveness?

For the purposes of this thesis, positioning is defined as those factors and strategic choices that orient research activities and university research operations towards or away from knowledge-intensive, innovation-focused activity – within research entities and across the university research sub-system. Effective positioning leads to enhanced research production, new fields of research, new

research entities, increased research visibility, more valuable knowledge, in other words, greater research activeness and research intensiveness. For the purposes of this study, the knowledge economy is defined as an economy whose characteristics include: (a) a significant proportion of economic activity is founded on knowledge-intensive, technology-enabled, innovation-focused production and distribution of goods and services, (b) there is significant demand for knowledge-intensive, technology-enabled, innovation-focused goods and services and (c) it is an economy that is evolving within the context of a services and industry-based national economy with strong linkages to the global economy.

The research sub-questions are:
(1) How does the university research paradigm and practice shift?
(2) In which ways is human capital a factor in the changing nature of university research activity?
(3) How do 21st century knowledge partnerships affect research activeness/ intensiveness at the university?
(4) Which themes of university change from emerging economy experience are pertinent to university research advancement in formative knowledge economies?

These questions enabled the researcher to explore the major challenges, obstacles and opportunities to repositioning universities in the emerging knowledge economy with respect to their research sub-systems and to formulate a relevant grounded theory.

1.8 Search for originality and key points related to framing the thesis

The subject of this thesis, the trends, tropes and positioning of the university in an emerging knowledge economy, raises many challenges for the researcher. One of the challenges is that this is not uncharted terrain and therefore originality

does not arise from an exploration of the unknown. Cryer (2006) refers to the "variety of interpretations and configurations of originality" and sets out a series of forms of originality in the PhD thesis, including originality in methodological tools/techniques/procedures, originality in exploring the unknown/unexplored/ unanticipated, originality in data/transfer of mode/place of use, originality in by-products, originality in the experience, originality as "potentially publishable".

For the purposes of this thesis, the search for originality led down the following paths: (i) originality in methodology, namely the utilization of grounded theory to search for new insights on the subject, other than that which is already theorized; (ii) originality in exploring the unanticipated, namely the strategy of positioning university research sub-systems; (iii) originality in data relevant to positioning strategy; (iv) originality in the research experience; (v) originality as 'potentially publishable', expanded on in Chapter 10.

This next section is intended to consider the framing of the thesis from a real world perspective, with only a brief reference to policy. It provides the background to the research problem statement, purpose statement and questions for enquiry. It is not intended to frame the policy debate at national level, nor at institutional level, because the study seeks understanding of actual events and processes, rather than public policy fit or institutional policy fit. The researcher accepts the abstraction of the knowledge economy as a partial explanation of the real world environment affecting universities, and does not engage with the knowledge economy as a policy construct. Thus, there is no critical analysis of policy, but rather a critical view of how a knowledge economy struggles to emerge in South Africa and India. Knowledge economy is used here as a contextual descriptor in a similar way to how one might use the term industrial economy or agro-industrial economy or services-based economy, as a way of understanding the particular dimensions of the real world economy. This particular thesis is interested in the knowledge economy context, rather than the

knowledge society context. It is noted that the use of the term knowledge economy in this thesis does not represent the full range of views held by the researcher on the meaning of this term. However, the objective here is not contestation about terms, rather it is the understanding of what is involved in the practice of university research production in endeavours to increase knowledge production and output.

1.9 Brief overview of South Africa as a reluctant knowledge economy

South Africa exhibits many of the features described by selected authors (Castells, 1996; Marginson, 2010; Perez, 2004) as being characteristic of an emerging knowledge economy. Strengths and weaknesses of the transition to a knowledge economy are apparent in the following five domains, guiding the researcher to frame the study:

(1) Globally competitive knowledge-intensive production and services in selected areas: New knowledge and resulting innovations in products and services have increasingly become drivers for business development and economic growth, including innovations in advanced materials for the engineering and construction industries, business process innovation in the financial services sector (Grulke, 2001), staying abreast of international trends in electronic banking services and in mobile commerce; in oil from coal technology and production; in the utilisation of bioscience in the wine industry; in software development (Addison, 2005a, 2005b; JCSE, n.d.a). These writings present evidence that innovation is today a wide-ranging and rapidly agglomerating phenomenon in South Africa. Indeed, with respect to technological innovation and advances in public healthcare, the effects of such innovation are of interest to social scientists quite as much as to health scientists, because these innovations and advances have society-wide effects at the level of the individual, the family, the community, multiple communities, affecting social health, social choice, lifestyle and broader generational social development. However, many parts of the economy remain relatively untouched by the transitions possible through

knowledge-intensive production, in particular large parts of the manufacturing sector are not engaged in knowledge-intensive production, despite a significant degree of technological innovation in products and services (Maharaj & Pogue, 2006, p.53). Agricultural production and government services have made only limited investment in increasing knowledge-intensity.

It is therefore appropriate to study institutions in the knowledge-intensive sector of the economy, in order to understand more about the nature of research production.

(2) Research and innovation: The country has a reasonably well-developed "national system of innovation" incorporating research and innovation in private firms and state-owned enterprises; in the statutory science councils and science engineering and technology institutions (SETIs), which engage in research in fields including the agricultural sciences, botanical sciences, geosciences, industrial sciences; in those universities that generate new knowledge and publish research including University of Cape Town, University of the Free State, University of Limpopo, University of Pretoria and University of the Witwatersrand (Wits); in the national research facilities that provide infrastructure for scientific research and in non-governmental public interest research organisations. In its R&D strategy, South Africa selected space science as one of only a few arenas for competitive science (Department of Science and Technology [DST], 2002) and mega-science projects include the South African Large Telescope (SALT) launched in Sutherland in November 2005 and the Square Kilometre Array (SKA) radio-telescope bid, which South Africa won jointly with Australia in 2013. The 10-year innovation strategy adopted in 2007 (DST, 2008) observes five "grand challenges" in frontier science including biotechnology, space science, clean energy, climate change and investment in the social sciences and humanities, but risks running to conclusion in 2018 with very limited advances to show in these research fields. Despite its relatively high

expenditure on R&D (HSRC-CeSTII, 2014 p. 6-76) and engagement in innovation activity, research and innovation is hampered by many factors including cost, knowledge and market factors (Moses, Sithole, Labadarios, & Blankley, 2011). Furthermore, in its extent of scholarly publishing, even though South Africa's research visibility was seen to be very low in 2006 and its share of articles in Web of Science hovered at 0.6 in 2012 and 2013 (Mouton, 2015; Scielo South Africa, no date; South African Journal of Science, 2009-2016; Tijssen, Mouton, van Leeuwen, & Boshoff, 2006).

During the period 2006 – 2013, South Africa's gross domestic expenditure on research and development (GERD) increased in nominal terms, but declined as a proportion of GDP, from ZAR18 billion or 0.95% of GDP in 2006/2007 (the highest GERD as a percentage of GDP) to ZAR23 billion or 0.76% of GDP in 2012/2013, indicating that investment declined as a percentage of GDP (HSRC-CeSTII, 2015, pp. 4, 6 & 7). Furthermore, investment in R&D has never reached the one percent of GDP targeted in public policy for 2008 onwards (DST, 2010). Universities spent approximately 20% or ZAR4.1 billion of this GERD in 2008/2009 increasing to over ZAR7 billion or 30% of GERD in 2012/2013 (HSRC-CeSTII, 2015, p.8). Science, engineering and technology (SET) research is a sizeable component of this expenditure.

Knowledge clusters and networks have formed, facilitated by research leaders in areas of work such as research on the human genome, innovative environmental science applications (Working for Water), in health technologies (iThembaLabs) and high quality services to poor and rural communities (Inkosi Albert Luthuli Central Hospital), in new energy sources (green energy strategies) and other fields (Addison, 2005; Diab & Gevers, 2009; Abrahams & Pogue, 2012). Despite the increasing levels of innovation activity, it is important to acknowledge that the declining investment in research as a percentage of GDP raises questions about the strengths and weaknesses of the research system as a whole and of

strategies within research universities in particular, with respect to increasing research activeness and research intensity.

The quaternary or knowledge-intensive sector in South Africa comprises of research-performing firms, research performing science institutes, research-performing universities and research performing NGOs. Early exploratory research at the commencement of this study led to a particular interest in gaining insight into the ways in which these institutions succeed in globally competitive knowledge-intensive production. However, it was not possible to study behaviour in all research-performing institutions.

The research performing university was chosen as the field of study because it offers a set of broadly similar institutions with broadly similar aims and objectives, where the findings and analysis are more likely to be valid and generalizable across a small sample, than would be the case with either firms or science councils, which tend to be more different than they are similar. For South Africa, this study refers to the 23 universities formed before 2013; while for India this study refers to the 43 central universities and the 52 Indian institutes of national importance founded before 2013. Strategic positioning in the university research sub-system is framed as the unit of study.

(3) Human resources as a foundation for the formative knowledge economy: South Africa is growing its quaternary or knowledge-producing sector through increasing the size and quality of its human knowledge base in key areas of international competitiveness, supporting the primary economic sector through new mining technologies and know-how; the secondary sector through beneficiation of mineral resources (example Mintek Jewellery Hub) and manufacture of automotive components (example Automotive Industry Development Centre); the tertiary sector through software accreditation for the electro-technical sub-sector (example Joburg Centre for Software Engineering).

South African researchers contribute knowledge for a range of productive sectors and for the solution of long-standing social and development challenges.

South Africa had 4.6 researchers per 1000 people in employment in 2008/2009, comparatively low, due to the failure of employment in the science, engineering and technology (SET) sector to keep pace with the rise in total employment. Of the total number of researchers, the largest proportion by headcount or 27,316 were researchers at universities, including doctoral students and post-doctoral fellows. Industry utilises significantly greater research funding than universities, over 60% of GERD as compared to 20% for universities, while it employs less than one-third of the total researcher population (DST, 2010). These trends continued through to the 2012/2013 survey year (the most recent survey year), where it was reported that there were 42,828 researchers by total headcount, of which 32,955 were employed in universities, including 15,514 doctoral students and post-doctoral fellows (HSRC-CeSTII, 2015, p. xiv). In summary, business expenditure on R&D (BERD) was 44% of GERD, while business employed 6,191 researchers; and university expenditure on R&D (HERD) was 30% of GERD, while universities employed 32,955 researchers (HSRC-CeSTII, 2015, pp. 31-43). According to the 2012/2013 survey report, labour costs utilised the largest proportion of R&D funds.

The peer review report on the South African NSI (Organisation for Economic Co-operation and Development [OECD], 2007), conducted in 2006, highlighted a number of issues that are relevant to the positioning of universities in a future knowledge-based economy (OECD, 2007, pp.4-11), in particular that business funding accounts for a larger share of university R&D than in many other countries, implying that there is lower public investment than in many other countries. The available knowledge infrastructure is articulated as a strength for the innovation system, but in reality it is small in relation to the overall size of the population. Listed as a threat, though this could be redefined as an opportunity,

are the demographic pressures on the education, research and innovation systems resulting from the sizeable increase in the cohort of people born in the 1990s. One of two 'looming crises' in HR supply and demand was noted, namely that the expansion of innovative activity would only be possible if it were balanced by considerable expansion of university research, while the current ageing profile of academics and scientists suggested that sustainability of university participation in the innovation system was at risk (OECD, 2007).

Views expressed at the OECD review workshop presentation in 2007 raised concerns about the capacity of South African universities to address the issues highlighted by the report (observation incident 1, 2007). The review document states (OECD, 2007, p.6):

> Another valuable national asset is a too small but good collection of established universities and a research institute (science council) system with core areas of considerable strength and experience. Centres of academic research excellence, mainly located in a nucleus of long-established universities, achieve high quality in several areas of research, as reflected in the presence of South African publications among the top 1% of internationally cited publications in several fields and in some cases in the higher quartiles of that group.

This brief review of the human resources trends raises issues of the relationship between research productivity and resource availability for university-based researchers and universities, in particular how university researchers produce research output with relatively low levels of funding, of interest for this study. While it also raises questions of resource utilisation efficiencies versus effects on socio-economic development, the latter focus is beyond the scope of this study.

(4) Digital networks and ICT services: While access to advanced technologies such as broadband are limited by lack of competition in the network segment of the market, South Africa has a vibrant ICT services sector. This ICT market supports home, work and public access to the Internet, to information, and to the rapid circulation and distribution of knowledge amongst producers and users.

The range of media and content provides the foundation for e-business, e-government, innovations in mobile banking, mobile commerce and other mobile services. The relative strength of South Africa's digital economy underlies its ability to participate in the global knowledge economy. In particular, ICT networks and Internet services provide a powerful source of access to information for scholars and postgraduate researchers at local universities, supporting access to research data, online publishing. High-speed broadband connectivity underlies the global research collaboration among South African universities and international collaborators on other continents, notably the ATLAS Experiment in high-energy physics at CERN (European Organisation for Nuclear Research).

(5) Public policy and framework conditions[1]: In the period 1996 to 2010, public policy evolved to promote governmental and private sector investment in knowledge-intensive activity in, inter alia, advanced manufacturing, biotechnology, ICT R&D, film and creative industries. Higher education policy principals, too, acknowledged the role of universities in developing human resources for a knowledge-based economy, as evidenced by the conference on Human Resources for Knowledge Production co-hosted by the Department of Science and Technology and the Department of Education in August 2005. However, higher education policy decisions, as expressed in the Green Paper on Higher Education (Department of Higher Education and Training [DHET], 2012a), in the review of the financing of higher education (DHET, 2012b), in the White Paper for Post-school Education and Training (DHET, 2013) and in the National Development Plan: Vision for 2030 (National Planning Commission [NPC], 2012), do not yet address policy to a knowledge economy paradigm.

[1] The term is used in the OECD review of the SA national system of innovation and is what the DST refers to as the economic and institutional regime.

This thesis regards South Africa as a reluctant knowledge economy, because most public policy, including the National Development Plan (NPC, 2011), either has not attempted or has failed to get to grips with the dynamics of economic and social change needed for globalised development. Despite relative silence on the part of public policy, major institutions and economic sectors, such as the banking and finance sector, the mobile communications sector and the university research sector, have been leading change. However, there is limited published research that addresses 21st century knowledge production complexities in the university research sub-system in South Africa (Cloete, Bailey, Pillay, Bunting, & Maassen, 2011, p. 125-139; Le Grange, 2012; South African Journal of Higher Education, 2012). Cloete et al (2011) argue that South African higher education policy and practice has not addressed itself in any significant way to the project of creating and utilising research-based knowledge for development, university leadership has shown little support for a knowledge economy approach, and (Cloete et al, 2011, p. 127):

> There was an emerging awareness about the importance of the knowledge economy approach, particularly in the Department of Science and Technology, but not in the Department of Education. Within the NMMU, it was surprisingly absent, except for specific pockets, mainly in the sciences.

While an understanding of the public policy environment for universities with respect to the knowledge economy is an important contextual element, it is not essential for theory building with respect to this study, because (i) there are no public policy pronouncements on universities in the knowledge economy from the DHET side and the public policy pronouncements from the DST side mostly address the doctoral output issue with respect to the university research environment; and (ii) this particular research problem is agnostic to any particular public policy environment, since it is about understanding the nature of strategic positioning with respect to research practice, in any policy environment. The dominant theme providing the context for this thesis is the theme of institutions in knowledge economy settings, with the particular choice of institutions being universities.

1.10 Schematic overview of South African universities R&D and innovation

Taking a knowledge economy perspective, the background for research-based universities in South Africa, with respect to research and innovation, human capital formation, adoption of ICT and Internet-based media services, and the prevailing public policy environment is presented here.

1.10.1 University explorations into research and innovation

South African universities are significant contributors to R&D and innovation across the natural, health, engineering and social sciences and humanities. A few examples[2] of exploring new avenues in scientific research, in the decade from 2003 to 2013, are reflective of a knowledge economy research orientation. The Centre for Rapid Prototyping and Manufacturing (CRPM) at the Central University of Technology (CUT), Free State, (visit, 5 September, 2003; observation incident 5, 2009) provides the environment for students and academics to conduct R&D for small firms and to work with manufacturing agents to commercialise innovations for the local and global markets. The Centre has produced the prototypes for low-technology innovations such as moulded gum guards for dental surgery and for low-cost, medium-technology driveable lawnmowers for golf courses and hotel lawns, providing a competitive alternative to high-cost imports. The Centre also developed processes to produce export quality clay pots with indigenous patterns, thus promoting craft exports for the community of the Basotho Cultural Village in the Golden Gate National Park. The multidisciplinary research encouraged collaboration amongst engineers, arts and management academics and the local and small business communities. The Centre, established as one of seven technology stations based at universities of technology under the Department of Science and Technology Tshumisano programme, sought to enhance the competitiveness of the small

[2] These vignettes were prepared by the writer and have been published in a co-authored publication for SAUVCA (Abrahams & Melody, 2005), but are revised and updated here

business sector, while simultaneously building the indigenous science and technology knowledge base.

The Inkosi Albert Luthuli Central Hospital (IALCH) in Cato Manor, KwaZulu-Natal (visit, September 19, 2003), has been supported by the University of KwaZulu-Natal's Nelson R Mandela School of Medicine. This collaborative partnership has offered advanced medical and healthcare services to people from poor and rural communities (Inkosi Albert Luthuli Central Hospital [IALCH], 2010). Healthcare services included emergency and trauma services, and specialist gynaecological, oncological and surgical services. Innovations included the use of advanced medical technologies, one of the first wireless communications records access systems to be introduced in a public hospital, as well as advanced food technologies that reduce spoiling and wastage. Specialist clinicians of the University of Kwa-Zulu Natal provide medical services in this technology rich environment. This public-private partnership models a triple-helix relationship of government-university-industry partnership (Etzkowitz & Leydesdorff, 1997), an approach where highly specialised knowledge and hi-tech infrastructure are made available to citizens from low-income communities, because of the innovative development finance model used.

Another example of university linked R&D activity was the work of the Gauteng Automotive Industry Development Centre (AIDC), a collaboration between the Gauteng Provincial Government and the Council for Scientific Industrial Research (CSIR), in which the AIDC collaborated with the automotive industry and with universities and technical colleges to introduce innovations in industry supply chain management, thereby introducing significant cost savings in the industry and investing in the development of highly qualified engineers and technicians (AIDC, 2003: pp.21 & 24). These university-business linkages were supported by the technology-focused Blue IQ growth strategy of the Gauteng

Provincial Government (GPG, 2002), as one among many efforts to promote sector competitiveness and increase long-term employment.

In these and other cases, universities are constructing the particular characteristics and evolving the role that they will play in the current and successive incarnations of the knowledge-based economy. It is therefore necessary to better understand the characteristics of university research production and the transition to research activeness and research intensiveness.

University-based research in South Africa has seen the growth of new disciplines such as computational molecular biology and its applications to bio-informatics and genetics; applications of computational applied mathematics to modelling the epidemiology of HIV/AIDS; and high technology research in pharmaceuticals and software development (Mouton, 2008; Wits, 2011; Wits, n.d.c). These are emerging areas of research and innovation at South African universities that integrate ICT with inter-disciplinary or multi-disciplinary research programmes, towards achieving the generation and application of new knowledge. These fledgling disciplines have required sustained human and financial investment to enable them to mature. Research-producing universities in South Africa have significantly increased their research productivity and their scholarly publishing in the decade to 2013 (CHET 2013a, Sheet 18; FFC, 2013), but limited data or analysis has been made explicit with respect to understanding the characteristics, contributions, barriers and challenges that universities face in becoming agencies of research and innovation.

1.10.2 Research resource context

Universities utilised nearly 20 percent of total R&D spend for the year of reporting 2008–2009, the approximate period of commencement of this thesis, see Table 1.1 below.

Table 1.1 Provincial Split of R&D 2008/09

	Business enterprise		Government		Higher education		Not-for-profit		Science councils		Total	
Province	ZAR 000	%	ZAR 000	%	ZAR 000	%	ZAR 000	%	ZAR 000	%	ZAR 000	%
Eastern Cape	316,089	2.6	107,929	9.5	286,605	6.8	6,790	2.8	171,669	5.5	889,081	4.2
Free State	1,213,808	9.8	58,697	5.2	226,892	5.4	4,673	2.0	58,561	1.9	1,562,720	7.4
Gauteng	7,131,411	57.8	264,273	23	1,467,914	35	126,136	52.4	1,991,853	64	10,981,587	52.2
KwaZulu-Natal	1,255,509	10.2	115,302	10	567,999	14	40,492	16.8	231,033	7.4	2,210,336	10.5
Limpopo	75,675	0.6	55,252	4.8	86,635	2.1	5,138	2.1	63,455	2.0	286,157	1.4
Mpumalanga	201,550	1.6	39,103	3.4	72,590	1.7	10,332	4.3	55,547	1.8	379,123	1.8
North-West	7,319	0.1	52,907	4.6	68,443	1.6	2,159	0.9	43,624	1.4	174,453	0.8
Northern Cape	222,630	1.8	70,741	6.2	150,125	3.6	2,339	1.0	41,541	1.3	487,376	2.3
Western Cape	1,908,020	15.5	375,473	33	1,264,162	30	42,500	17.7	480,059	15	4.070,214	19.3
Total	12,332,012	100	1,139,676	100	4,191,366	100	240,649	100	3,137,343	100	21,041,046	100

Source*: DST 2011, National Survey of Research and Experimental Development, 2008/09*

It is noted that the concentration of R&D funding flows to the higher education sector was to the Western Cape and Gauteng provinces, accounting for 56% of higher education R&D funding. The higher education portion flows to mainly four universities in these provinces, namely the University of Cape Town, University of Pretoria, University of Stellenbosch and University of the Witwatersrand, partially through competitive funding processes. The remaining 44% is shared disproportionately amongst 19 universities, with the distribution of funds dependent on the research productivity of the particular institution. In this skewed research-funding context, some research-performing universities produce approximately 100 publication output units (University of Venda, 2012), while the research-intensive universities produce approximately 1000 publication units per annum (University of the Witwatersrand, 2012b, p.29). This data,

amongst others, indicates that South Africa has experienced a co-evolution of inequality with the innovation system, (i) with respect to participation in the innovation process and (ii) with respect to which parts of society experience the benefits of innovation (Abrahams & Pogue, 2012). This means that the existing public funding for research performed at universities is producing only limited benefit flows to economy and society and limited development impact.

Telecoms network infrastructure and Internet services are key resources for universities, who are introducing e-learning (University of the Western Cape), while also creating online research repositories and e-journal portals (University of Pretoria, University of Stellenbosch, University of Witwatersrand) (South African Institute of Distance Education [SAIDE], 2007). Universities have been high-bandwidth users, being amongst the stakeholder groups driving current demand for broadband in South Africa (Tertiary Education Network [TENET], n.d.). Universities have been interested in new modes of access to knowledge, made possible through access to the Internet, namely open access to scholarly literature, based on alternative approaches to copyright and alternative licenses such as creative commons licenses (Wits, 2012b).

Access to funding, whether for existing or new research programmes, for laboratory or ICT infrastructure, has been a constant objective on the agenda of every senior academic, researcher and university advancement programme. Enterprise and entrepreneurialism have increasingly presented the main opportunities for South African universities to access future funding resources as government funding of students, dedicated government research grants and innovation funds, donor-based grant funding and business-linked research funding has been spread thinly across the South African university sector.

1.10.3 South African public policy for university research and innovation

The Department of Higher Education and Training (DHET), responsible for fostering an enabling environment for universities, emphasises the importance of

high volumes of undergraduate enrolments (DoE, 1997; DHET, 2013) and recognises the necessity of university research production to address development needs, however the most recent policy statement proposes to introduce only limited support measures to promote research activeness (DHET, 2013, pp.34-35). The 2013 policy document, the White Paper for Post-School Education and Training proposes support measures with respect to research infrastructure, IT infrastructure, access to local and international journals, participation in global research networks, as well as postgraduate students and postdoctoral fellows (DHET, 2013, p.35), however the statement is too generalised to make specific interpretations about its real stance on universities in the knowledge economy.

Universities such as Wits and UCT have adopted strategies which aim to increase the relative size of their postgraduate populations, thus creating the human capital for indigenous science and technology and research production, as well as educating future generations of academics and researchers. Public policy pronouncements require that South Africa produce 5,000 PhDs per annum as compared to the historical level of 1,500 PhDs per annum (NPC, 2011, p.278) and the research-intensive universities would have a major role to play in this regard from the perspective of postgraduate research design and supervision. Working towards this target will require major changes in pedagogical approaches at undergraduate level and in pedagogy and supervision at postgraduate level, to promote preparedness for postgraduate study and research production, changes not yet introduced. While science and technology policy saw universities as key players in the new landscape of the national system of innovation, higher education policy has (correctly) been concerned with increasing the participation of South Africans, but (regrettably) has paid scant attention to participation in terms of undergraduate transition to postgraduate study, or in terms of postgraduate and academic research production (DHET, 2012).

1.11 India and BRICS countries emerging economy perspective

For the purposes of understanding the university research context, it is necessary to consider trends in emerging economies, which are shifting their positioning in global R&D participation. Mashelkar (2008, p.299) discusses the future of India amongst other "innovative developing countries", including Argentina, Brazil, Chile, China, Egypt and South Africa. He notes that the economic strength of countries appears to be dependent to some degree on the availability of human resources to produce science and technology-based products and services indigenously and comments on the stagnation in Indian scientific research over several centuries as retarding economic growth in the 21st century. This view is partly drawn from King (2004), who presented evidence that a positive correlation existed between national citation intensity (the ratio of the citations to all papers to the GDP) and national wealth intensity (GDP per person), which could be interpreted to mean that countries with a relatively large, highly talented workforce who widely publish knowledge arising from their scientific endeavours contribute to high economic strength in those countries. The OECD referred to the use of citations as a "quality-adjusted" measure of research output (OECD, 2011, p.94).

1.11.1 Increasing research capability in innovative developing countries

In the decade of the 1990s, India and other innovative developing countries were increasing their research capability. Various studies (King, 2004; OECD, 2009; OECD, 2011) report increasing research and innovation intensity in a number of emerging economies, in particular with respect to a group referred to as the BRICS[3] countries. These five innovative developing countries were increasing their R&D capability in the period 1997-2001 compared to the period 1993-1997 (King, 2004, Table 1, p.312). With respect to India, the contribution of Indian universities and colleges to SCI[4] publications with low and medium normalised

[3] BRICS are Brazil, Russia, India, China and South Africa

[4] SCI is Science Citation Index

impact factors was significant, as observed in a scientometric study of Indian science publication for the year 1997, with published research mainly in the physical sciences, chemical and medical sciences (NISTADS, 2006: p. 47-48). While these statistics related to the decade prior to this thesis, they provided a useful foundation for understanding the research and innovation context of universities in selected emerging economies. Table 1.2 below sets out a view of the BRICS nations share of publications and citations for the period 1997-2001 (King, 2004, Table 1, p.312) relative to the top global producers, noting that India's publications and citations are in the mid-range and South Africa's publications and citations are at the bottom end of the BRICS group, further noting that these statistics are not adjusted for population or GDP.

Table 1.2 BRICS nations share of top 1% of highly cited publications, 1997-2001

Country	**Publications and percentage of world total**	**Citations and percentage of world total**	**Top 1% of highly cited publications and percentage in comparator group**
US	1,265,808 = 34.86%	10,850,549 = 49.43%	23,723 = 62.76%
EU 15 total	1,347,985 = 37.12%	8,628,152 = 39.3%	14,099 = 37.3%
Japan	336,858 = 9.28%	1,852,271 = 8.44%	2,609 = 6.9%
Russia	123,629 = 3.4%	315,016 = 1.43%	501 = 1.33%
China	115,339 = 3.18%	341,519 = 1.56%	375 = 0.99%
India	77,201 = 2.13%	188,481 = 0.86%	205 = 0.54%
Brazil	43,971 = 1.21%	155,357 = 0.71%	188 = 0.5%
South Africa	18,123 = 0.5%	67,916 = 0.31%	81 = 0.21%

Source: *King, 2004*

Among the BRICS countries, India and South Africa provided interesting cases for the study of changing practice in university research as their university research systems confront complex challenges in increasing their research activeness. In particular, these two countries offered pragmatic access to data

collection and interpretation for this researcher because they are both English language environments.

1.11.2 Key statistics for India

In 2001, India had thirty-five metropolitan cities with populations of more than one million, six mega cities with populations of more than five million and three mega cities of more than ten million people (Premi, 2006). These metropolitan and mega cities hosted the majority of India's central universities and Indian institutes of national importance. India's population estimate in the 2011 census was 1,21 billion living in 249,501,663 households (Government of India [GoI], 2011), while GDP in 2010-2011 was estimated at INR77953,13 billion (Reserve Bank of India [RBI], 2013, p.5), or approximately ZAR11634,79 billion. The population estimate for the period 2007-2008 when this study commenced was 1,13 billion and the GDP estimate was INR49870,9 billion (RBI, 2013, p.5), or approximately ZAR8311,8 billion[5]. The Human Development Index (HDI) for India was 0.525 in 2007 and 0.551 in 2011, while the HDI for South Africa was 0.609 in 2007 and 0.625 in 2011, reflecting high poverty levels (United Nations Development Programme [UNDP], 2013, pp.149-150).

1.11.3 Science and technology indicators for India

Input indicators pertaining to research and innovation investment include gross domestic expenditure on research and development (GERD), which was recorded as PPP$[6]24.8billion for India and PPP$4.2billion for South Africa for the year 2007 (DST, n.d.; OECD, 211; United Nations Educational, Scientific and Cultural Organisation [UNESCO], 2011). This translated as 0.76 percent of GDP for India and 0.93 percent of GDP for South Africa for 2007 (DST, n.d.). Despite comparatively low science and technology investment as indicated above, as well as the historically low contribution of state research funding to higher education

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[5] Conversion from INR to ZAR based on historical exchange rates from www.xe.com of 6.7 for 1 January 2011 and 5.8 for 1 January 2008

[6] PPP$ is dollars at purchasing power parity

(National Knowledge Commission [NKC], 2006), Indian universities operated in a research active context where a culture of innovation has been nurtured by local and multi-national funding and by the ability to respond to particular areas of demand from global markets: India was listed 10th amongst the top manufacturing nations; is engaged in international innovation collaboration with high GERD nations Sweden, Finland and Belgium; and experienced significant annual increases (above 20%) in international flows of science and technology related royalties between 1997 and 2009 (OECD, 2011, p.35; p.106; p.108). However, publication quantity and quality per thousand population was comparatively low and the country generated a comparatively low proportion of breakthrough inventions (OECD, 2011, p.94 & p.192), while its global innovation index ranking was 35.7 (out of a possible 100) in 2012 (UNESCO, 2012), lower than the other BRICS countries. Hence, India's research institutes and research-oriented universities have faced a high degree of research complexity in their future path towards increased research activeness and research intensiveness.

The overview of research context was important because universities in emerging knowledge economies have encountered significant challenges in demonstrating and building advanced research capabilities. This has been partly due to the particular circumstances of the national innovation ecosystem in each country, which may exist in a formative stage and where important components of the research ecosystem may be embryonic, such as the capacity for supporting relationships amongst universities and other research producers or research funders.

1.11.4 Evolution of Indian higher education and universities

The Indian higher education system developed in the period from the 1950's to 1970's supported by the contribution of institutional science architects, such as Sarabhai, founder of the national space programme and the Indian Institute of Management (IIM) in Ahmedabad (Narasimha, 2008). Universities formed in the

early 1900's, for example Visva-Bharati established at Santiniketan by Nobel Laureate Tagore in 1901 and declared a central university in 1951 (Visva-Bharati University, n.d.) have been highly influential in the higher education landscape. In 1947, there were only 38 engineering colleges and 53 polytechnics with a combined intake capacity of less than 7,000 students; while by 2007, the number of institutions for technical education had increased to more than 5,000 technical education institutions (All India Council for Technical Education [AICTE], 2007), as well as 43 central universities, 52 institutes of national importance, 312 state universities, 130 deemed universities and 174 private universities (University Grants Commission [UGC], n.d.). There were many more higher education institutions that were not recognised by the University Grants Commission (UGC) for financing and other purposes. This research is interested in universities and institutes of technology in India, as they are research active and are appropriate institutions of study in terms of the research problem of research activeness and intensiveness.

In the early 21st century, Indian universities and institutes of technology were advancing their levels of knowledge production in various spheres, including in the software engineering and biological sciences (Narasimha, 2008). Specific recommendations on higher education reform were proposed by the National Knowledge Commission (NKC) in November 2006, including establishing new universities to achieve a complement of 1500 universities in eight years, including 50 national universities; an independent regulator for higher education responsible for promoting higher standards; and measures to turn universities into research centres. The report stated (NKC, 2006, p.43-44):

> **Create many more universities.** The higher education system needs a massive expansion of opportunities, to around 1,500 universities nationwide, that would enable the country attain a gross enrolment ratio of at least 15 per cent by 2015…The commission recommends the creation of 50 national universities that can provide education of the highest standard. As exemplars for the rest of the nation, these universities shall train students in a variety of disciplines, including humanities, social sciences, basic sciences, commerce and professional subjects, at

> both the undergraduate and post-graduate levels. The number 50 is a long-term objective.

The NKC, a high-level advisory body to the Prime Minister of India, had the objective of providing the requisite guidance required for transforming India into a knowledge society. Its terms of reference included promoting change in the education system to "meet the knowledge challenges of the 21st century and increase India's competitive advantage in fields of knowledge" and to "promote creation of knowledge in science and technology laboratories" (NKC, 2006).

It has been argued that change in the Indian higher education landscape has been spurred by increasing participation of India's companies and universities in the globalisation of knowledge, by multinational businesses locating their production and research centres in Indian, by the demographics of a majority youth population under the age of 24 with a heightened demand for higher education; by high national expenditure on higher education for Indian nationals abroad; by the gap between qualifications and job readiness for large numbers of graduates; and other factors (AICTE, 2007; NKC, 2006). The societal demand for highly qualified young professionals in fields such as the health and medical sciences has been great (Supe & Burdick, 2006), while a study by McKinsey and the National Association of Software and Services Companies of India (NASSCOM) concluded that the information technology (IT) and business process outsourcing (BPO) sector would face a shortfall of half a million skilled workers by 2010 (NASSCOM McKinsey, 2005). The demand for research from universities, other higher education institutions and research institutes, as well as the demand for future generations of researchers and scientists has been perceived as equally important (Chakrabarti, 2007; Dutta, 2012; Gupta & Dhawan, 2009; King, 2004; Mashelkar, 2008; Narasimha, 2008; Sevukan & Sharma, 2008; VijayRaghavan, 2008).

1.12 Chapter summation: The need for theorising the positioning of universities in the 21st century knowledge economy

In 2002, the then Minister of Education announced the mergers of South African universities and technikons. This followed initiatives to reconfigure the higher education system to meet education policy objectives including more efficient and equitable distribution of the higher education budget; a significant increase in the numbers of people graduating from the system; alignment of the knowledge and skills of graduates to the future needs of South Africa. In 2007, India adopted a new university system, incorporating government support for academic research.

At the time of this significant set of events in the South African higher education landscape, the mergers were certainly a necessary measure to address decades of historical imbalances resulting from the social inequities of apartheid. However, from the perspective of other policy arenas – economic policy, trade and industrial policy, and science, technology and innovation policy – another question could be posed. If South Africa was to be capable of addressing its past socio-economic inequities and backlogs, as well as prepare itself to avoid future-lags, how would universities provide the requisite knowledge base for 21st century development?

In the intervening decade, universities in India (national universities and Indian Institutes of Technology) and South Africa (research universities, comprehensive universities and universities of technology) have experienced observable transitions in their research activeness and research intensiveness. As will be discussed in Chapter 2, the available body of literature does not explicitly present an understanding of what enables some universities to make these transitions, while others do not. Therefore, the theoretical framing for this thesis takes account of the concepts and theories prevalent in academic literature, but attempts to move beyond these boundaries of description and analysis.

The advantages of building new theories to explain university research activeness and research intensiveness would be valuable beyond the study countries and study institutions discussed in this thesis. New theories would be beneficial to university positioning in all emerging knowledge economies as these new theories could offer a broader canvass of understanding than is currently available.

Chapter 2 Framing the university transition from research activeness to research intensiveness

A vast scholarly literature exists on the subject of universities and much has already been written in endeavours to explain university transitions in the emerging knowledge economy. This chapter reviews literature applicable to universities and knowledge-based economies, addressing in particular the changing characteristics and practices of universities with respect to the production of research and of innovation outputs. It notes the debate and theorisation that has occurred over the period prior to the thesis research (prior to 2008) and uses the theory to provide a backdrop to the study. It discusses research and theory during the period of the thesis study (2008-2014), the evolution of theory and the insights gained from this theory, particularly with respect to developing countries. It illustrates one of many remaining gaps in knowledge that exist with respect to understanding the positioning of universities in the knowledge economy, specifically with respect to activities within the research sub-system.

There has been some debate on the implications of the knowledge economy for South African universities (Badat, 2008; Badat, 2012; Le Grange, 2012; SAJHE, 2012; Vale, 2008) and on the role of universities in economic development on the African continent (Cloete, Bailey, Pillay, Bunting & Maassen, 2011; Mouton, 2008). This debate has endeavoured to explore opportunities, *inter alia*, for strengthening the national system of innovation (NSI), particularly with respect to the broad fields of the natural sciences and engineering, and the health sciences (DST, 2002; Mouton, 2008). Less attention has been given to the social sciences and humanities, yet these are important arenas for considering heightened knowledge intensity and the increasing value of knowledge to society. This SAUVCA[7] statement from *A Vision for South African Higher*

[7] SAUVCA became Higher Education South Africa, HESA in 2006, then became Universities South Africa in 2015

Education, made more than a decade ago, is one of the earliest statements on universities in the knowledge economy in South Africa (SAUVCA, 2002: p.6):

> The knowledge economy – an economy in which applied information is used in all sectors to improve productivity and seek competitive advantage through innovation – has had a fundamental impact on universities as producers of knowledge. Universities need not only to keep abreast of socio-economic changes in the global environment, arising from the unprecedented rate of production of new knowledge and scientific or technological innovations, but also to find an appropriate place for them to flourish in this landscape. The role of universities and other higher education institutions in the knowledge economy is therefore a critical question confronting SAUVCA and South African higher education. It has many implications – not least for planning – all of which require the investment of significant energy and resources.

Unlike Vale (2008, p.212), the framing of this study does not regard the term knowledge economy as a preoccupation of higher education policy-makers and planners, nor as an economic paradigm that pushes for "the increased value accorded to the technical end of knowledge" (Vale, 2008, p.213). Rather it finds the term knowledge economy a useful abstraction that takes thinking beyond the confines of the industrial economy or the services-based economy as modes of development, a term that addresses knowledge creation in many forms, revealing a techno-economic revolution that affects economy and society in a comprehensive transformation (Perez, 2010). The broader term, knowledge society, is not used here, however, the researcher holds the view that knowledge creation for society and economy are inter-related. It is further noted that, in the 21st century, technological advancement penetrates the humanities and social sciences quite as much as it does the natural, engineering and health sciences, with engineering, design and communications technologies becoming artistic, cultural and analytical artefacts and tools in these domains of knowledge, amongst others.

2.1 Identification of gap in knowledge

The purpose of the conceptual and theoretical review outlined in this chapter was to create a theoretical frame in order to move beyond the historical discussion into the realm of exploratory theory, because there has been limited published theory on the transitions and positioning of university based research from an emerging economy perspective. There is extensive published research on what universities are doing in the knowledge economy – they are entrepreneurial, they contribute to economic development, they engage in technology transfer, and particular factors affect their performance. However, the academic literature has provided little theorisation dealing explicitly with how universities engage in positioning themselves in the knowledge economy and the complexities associated with this positioning. The experience of positioning universities in the 21st century knowledge economy to become research active and to achieve greater research intensiveness was a gap identified in the available scientific literature.

The review of concepts and theory in this chapter therefore conveys the theoretical influences on the research investigation conducted for this grounded theory study. The theory formulated in the thesis does not build on pre-existing theory on university research and university positioning. Instead, it adds to the body of knowledge pertaining to the trends and tropes in universities through grounded theory formulation.

2.2 Key themes relevant to universities in emerging knowledge economies

Countries or economic regions in which the trends in universities in knowledge economies have been extensively theorised (Atkinson & Blanpied, 2008; Etzkowitz & Leydesdorff, 2000; Etzkowitz, Webster, Gebhardt & Terra, 2000) can be characterised as high-knowledge intensive, high-technology intensive environments, like the US, UK or particular countries in Europe, with evolved national systems of innovation (Freeman, 1994, 1995; Lundvall, 1998; Perez, 1983,

2004, 2010). Major themes in the applied field of higher education in this context include theories of the "dynamics" of university change (Altbach, 1998; Birnbaum, 1988; Clark, 1972, 1983, 1995, 1998b, 2001; Olsen, 2007; Pinheiro, 2012; Pinheiro et al, 2014); the globalisation and internationalisation of higher education (Beerkens & Derwende, 2007; Gibbons, 1998; Sadlak, 1998; Teichler, 2004); key features of the "emerging global model of the research university", including the role of the university in economic development, the "capitalisation" of knowledge, entrepreneurialism and entrepreneurial science (Deem, 2001; Etzkowitz, 1998; Etzkowitz, 2002; Etzkowitz & Leydesdorff, 1997; Etzkowitz & Viale, 2010; Mohrman, Ma & Baker, 2007; Palfreyman & Tapper, 2009, pp.209-210; Shattock, 2009); the "new" production of knowledge, including marketization and competition in higher education (Gibbons, Limoges, Nowotny, Schwartzman, Scott & Trow, 1994; Marginson, 2006; Palfreyman & Tapper, 2014); and the role of the state in regulated markets for higher education (Palfreyman & Tapper, 2014). South African scholarly writing on higher education includes investigations of research development (Christiansen & Slammert, 2005), research quality (Besley & Peters, 2006), and organisational barriers to creativity (Garnett & Pelser, 2007). Furthermore, key themes in the literature on innovation studies include theories of techno-economic revolutions and transitions (Freeman, 1994, 1995; Geels & Schot, 2007; Lundvall, 1992; Perez, 1983, 1985, 2004, 2010) and are eminently applicable to university research sub-systems.

Other themes in the literature include rankings; managerialism and strategic science regimes; academic labour markets; access, inequality and exclusion versus massification in higher education, themes that did not arise during the evidence-gathering phase of this study and are therefore not further discussed here.

These key themes in the literature derive from the experience of countries that are relatively more advanced with respect to the evolution of their knowledge-based economies, including the US, the UK, Japan and countries of the European Union, countries which have reasonably highly evolved science, technology and innovation landscapes. However, the majority of developing countries do not have well-developed science, technology and innovation (STI) systems or landscapes, investing very little in research or innovation. South Africa and India, have similar levels of R&D investment, below 1% of their respective GDP, India spending 0.82% of GDP and South Africa spending 0,73% of GDP in 2011, while India's high technology exports increased to USD17,3 billion in 2014 and South Africa's high tech exports increased to USD2,4 billion, in comparison to Singapore, whose high tech exports reached USD137 billion and China, whose high tech exports reached USD558 billion in 2014 (current US dollars) (The World Bank, 2016).

Less often has research been published on university research transitions in developing countries like China (Wu, 2007; Mohrman, 2008), at least in English language academic journals. From circa 2006, more research has been published on universities in formative knowledge economies in low- or medium-knowledge intensive countries, including on the themes of the nature of the 21st century university (Altbach, 1993, 2003; Chhokar, 2010; Higgs, 2006; Horsthemke, 2006; Imenda, 2006; Le Grange, 2012; Gupta & Gupta, 2012; Narasimharao, 2009; Prinsloo & Louw, 2006; Supe & Burdick, 2006; Waghid, 2005; Van Zyl, Amadi-Echendu & Bothma, 2007); bibliometric and scientometric studies of research publication (Arunachalam, 2002; Gupta & Dhawan, 2009; Pouris, 2003; Pouris, 2012; Sevukan & Sharma, 2008; van Zyl, 2012); improving research quality (Maürtin-Cairncross, 2005; Peters, 2006); participation in innovation and economic development (Reveiu & Dardala, 2013), entrepreneurial universities [in South Korea, Indonesia, Russia] (Betz, Min & Shin, 2013; Payumo, Arasu, Fauzi, Siregar & Noviana, 2014; Uvarov & Perevodchikov, 2013) and the triple helix of

university-industry-government relations [in Indonesia] (Ery Supriyadi, 2012), technology transfer (Bubela & Caulfield, 2010; Conceicao, Heitor & Oliviera, 1998b) and institutional development (Mentz & Mentz, 2005; Schulze, 2006; Supe & Burdick, 2006).

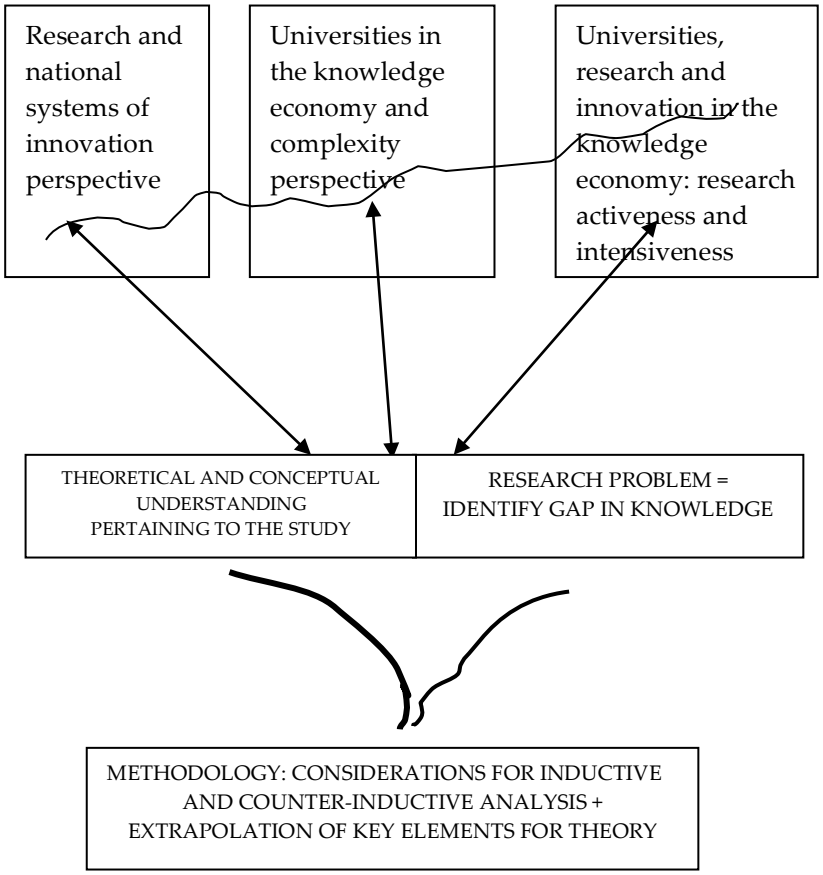
Economies on the African continent, in East and South East Asia and other parts of the developing world have experienced particular historical trajectories with respect to the evolution of their economies as science-based or research-based economies (Abrahams & Pogue, 2012; Conceição, Heitor & Oliviera, 1998a; Joseph, Singh & Abraham, 2014; Marginson, 2010), while the evolution of universities in these economies is being partly shaped by the demand for knowledge (Wong, Ho & Singh, 2007; Wu, 2007). The low levels of availability of resources for STI in developing countries, human, infrastructure and financial, set structural limitations on the capacity of universities to be research and innovation productive. Under these conditions, the approaches typical in more advanced knowledge economies may be sub-optimal or not applicable. For example, there is disagreement on the benefits and dis-benefits of marketization of university-based knowledge in the UK (Palfreyman & Tapper, 2009). In developing countries, even in BRICS countries (Brazil, Russia, China, India, South Africa), universities are among the relatively few institutions that provide knowledge resources for commercialisable research, hence universities may offer an important platform for research that makes marketization highly desirable. It may be that, in many developing countries, the low levels of firm or corporate investment in R&D and the limited private research infrastructure means that the available research infrastructure in universities could be most beneficial through utilisation towards some form of marketization. Thus, it was necessary to understand key aspects of the discourse, without choosing to predicate the research on the existing theory. The researcher can be open to thinking through new typifications of the issues pertaining to universities.

The debate engaged in here relates to questions about how the emergence of a knowledge economy in a developing country context relates to the changing characteristics and practices, the role and positioning of universities. The chapter adopts the view that all societies throughout history have been knowledge societies, however they can be distinguished from each other by analysing the role that knowledge plays in the creation and replication of social relations, the ways in which knowledge is created and disseminated, and the contribution that knowledge makes to economies. In industrial societies, knowledge appears to be subjugated to other factors of production, namely land and capital, or tacitly embedded in labour (Rothwell, 1992). In a "network, knowledge economy" (Melody, 2002), knowledge becomes externalised as a factor of production and becomes a source of development (Castells, 1996; Rothwell, 1992), and knowledge is mediated and distributed across networks, creating what Benkler (2006) calls "the wealth of networks".

Scholarly publishing in the categories discussed above recognise the major global and local influences entirely reshaping higher education. What is missing from the scholarly writing is a conceptual and theoretical engagement with respect to the positioning of the university research sub-system, in a globalizing, knowledge-oriented economy and society. In the period prior to commencement of this study, there was limited writing on this subject. Subsequently, new writing has emerged, for example, research on the emergence of independent and university-based technology hubs, discussed later.

The literature review is written in six parts (i) universities in the knowledge economy (ii) research and innovation in the knowledge economy (iii) universities, research and innovation in the knowledge economy (iv) theoretical and conceptual understanding pertaining to the field of study (v) clarification of the gap in knowledge, as presented in Figure 2.1 below.

Figure 2.1 Map of themes from scholarly literature



The literature review examines the changing paradigms for university-based research. It explores the themes of the rise of entrepreneurial universities and entrepreneurial science, the role of universities in economic development, national systems of innovation, technology transfer and commercialisation of knowledge. It comments on research on university change from the perspective of highly complex institutional memes that promote or disfavour research production. These were important themes and trends, visible with respect to leading international universities and universities in developing countries, which provides a conceptual environment within which to think about universities in knowledge economies. This foundational discussion provides the basis from which to explore beyond the themes, addressing the gap in knowledge with respect to research activeness and research intensiveness.

2.3 Knowledge economy and national systems of innovation perspective

Lane's (1966, p.650) article was one of the earliest post-war contemplations on "the knowledge age" in which he postulated five characteristics, namely philosophical/ theoretical inquiry, application of scientific rules of evidence in research, investment of resources in research and knowledge production, organising and extracting meaning from research, and using the knowledge gained to advance societal goals. Subsequently, other theorists have attempted to describe, define and analyse the forms and practices of late 20th century and early 21st century knowledge economies.

2.3.1 Theorisation of knowledge economy and society

Among the many theorisations of knowledge economies, a few are highlighted here to illustrate the progression in thinking on the subject. Stehr (1994, p.9) argued that:

> Theories of modern society lack sufficient detail and scope in their conceptualization of the 'knowledge' supplied, the reasons for the demand of more and more knowledge, the ways in which knowledge travels, the rapidly expanding groups of individuals in society who, in one of many ways, live off knowledge, the many forms of knowledge which are considered pragmatically useful, and the various effects which knowledge may have on social relations.

While there has been extensive research on knowledge societies in the past two decades, giving significant insight into the questions posed by Stehr, yet "the ways in which knowledge travels" remain poorly understood.

For Perez (1983, 1985, 2004, 2010), scientific or techno-economic revolutions may be contemplated in terms of long waves of change, whence she refers to five such Kondratiev waves, building on the work of Kondratiev (1935) on "long waves in economic life". The fifth techno-economic revolution, what Perez calls the "age of information and telecommunication", equates with the conceptualisation of a knowledge economy(ies) or knowledge-based economy(ies), introduced by low-cost micro-processors and their data management capability and the advances in

national and global telecommunications infrastructure. The storage and sharing capacities of the information and communications technologies (ICT) enables new forms of innovation premised around the digital transformation of industries and of knowledge production. She raises the following key issues pertaining to the relationship between the fifth techno-economic revolution and "institutional requirements for the next upswing (Perez (1983, p.372):

> In particular the precise detection of the characteristics of the new paradigm is essential to point to the institutional solutions, which, at the same time as they open the way for the generalization of the new paradigm, find the appropriate solutions to make the lot of those who would have been its inevitable victims less painful or even better.
>
> This is not to say there is a one-to-one correspondence between the general characteristics of the technological style and those of the adequate socio-institutional framework. We have already emphasized that there can be a wide range of scenarios, all valid as far as making high rates of growth possible…

and Perez (1983, p. 374)

> Overall though, a very salient characteristic of the new technological system is its capacity to cope with variety, diversity and dispersion at all levels, as opposed to the prevailing need for 'massification', homogenization, and agglomeration typical of the paradigm about to be replaced. This might mean that the range of valid scenarios is particularly wide and furthermore, that these might be capable of accommodating an even wider range of social choice and institutional arrangements at the micro level.

The points made by Perez (1983), as cited above, with respect to the socio-institutional styles that may arise or be necessary at any point in the fifth long wave was strongly influential in the early thinking leading to the framing of the research problem with respect to research activeness and research intensiveness and the applicable transitions.

Lundvall (1992) introduces the discussion of national systems of innovation, meaning the interconnectedness of various innovation-producing forms of organisation, including firm- or industry-based research production, university research production, policy-making and financing. Foray and Lundvall (1998,

pp. 115-122) offer a discussion on the connections between the knowledge-based economy and the learning economy, both sets of terminology being about assigning meaning to observable forms of economic arrangement. Freeman (1995) gives a brief history of the debates on national innovations systems and the place of university research in this system. da Motta e Albuquerque (2007, 669) refers to the "problems of building NSIs at the periphery". Texeira (2014) notes varying approaches to the utilisation of the NSI theory, including that it can be used as an analytical framework, however there is limited methodological guidance for "empirical system mapping". She draws attention to weaknesses in the literature, citing Lorentzen (2009), notably "plenty of description but limited analysis".

Castells introduces the concept of the information revolution into the discourse, an advance on Richta's (1969) concept of scientific-technological revolution and Perez (1983) work on the fifth long wave of techno-economic change. Castells (2000) set out key features of the new economy as being global knowledge based productivity (pp.69–147), a networked economy (p.67) based on the linking of valuable market segments across countries into a global network of production (p.85), fostered by the information revolution (pp.29–65) which enabled information flows, technological capacity and education for competitiveness (pp.103–104).

As regards the theme of human capital for knowledge economies, Melody (2002) argues that human capital is the foundation of the network knowledge economy and notes the elements of triumph and tragedy; triumph in its ability to foster great leaps in knowledge, tragedy in its inability to include larger numbers of people in economic life. He points to the role of universities in moving larger numbers of young people up the knowledge 'value chain' in order to function effectively in this emergent economic era. Little has been written on the gender-related aspects of knowledge-producing human capital, or the participation of

excluded groups (McCowan, 2007; Naidoo, 2004) by virtue of being poor or rural, linked to the importance of diversifying participation in the knowledge workforce. Such participation can strengthen disciplinary, inter-disciplinary and geographic knowledge bases, through introducing greater diversity of knowledge, experience, research interests and ways of understanding societal problems.

Friedman (2006: pp.11–12) discusses the particular complexity of the networked knowledge era:

> … the tools that are crucial to improving productivity become more and more complex with each new generation, and therefore they require more and more knowledge and training to get the most out of them…It is no surprise, therefore, that those societies with the most innovative scientists, universities, engineers and technology companies able to solve complex problems … have enjoyed rising standards of living over those societies without them…The time in which any breakthrough remains ahead of the pack is steadily getting compressed, and to achieve each breakthrough requires mastering and aggregating more and more complexity. When time is compressed and complexity intensified, knowledge becomes a greater and greater asset.

Moving beyond the theory of national innovation systems, Geels and Schot (2007) discuss socio-technical transition pathways and propose a typology of such transitions, a multi-level perspective of niche-innovations, the socio-technical regime and the exogenous socio-technical landscape. Most importantly for the methodological work of this thesis, they state that "Authors have proposed different pathways in transition processes, often illustrated with single case studies", providing reasonable guidance that a limited number of case studies can contribute to the understanding of socio-technical transitions.

Elaborating some of the nuances in theorising knowledge economies, Carayannis and Campbell (2011) presented a blend of the concepts of open innovation, a fractal innovation system, quadruple and quintuple helix arrangements and mode 3 knowledge production systems. What at first appeared to be a conceptual

soup, was in reality a careful explication of the rapidly increasing complexity of knowledge economies, in which the media-based and culture-based public and civil society direct or reinforce the evolution of highly flexible innovation systems (the quadruple element of the helix) and the natural environment informs knowledge production (the quintuple element of the helix) (Carayannis & Campbell, 2011, p.366):

> Mode 3 (mode 3 knowledge production), in combination with the widened perspective of the quadruple helix and quintuple helix (quadruple and quintuple helices innovation systems), emphasizes an innovation ecosystem (social and natural systems and environments) that encourages the co-evolution of different knowledge and innovation modes as well as balances nonlinear innovation modes in the context of multilevel innovation systems. Hybrid innovation networks and knowledge clusters tie together universities, commercial firms, and academic firms.

The bias towards the natural, health and engineering sciences was a strong theme in the literature on the knowledge economy. While the arts and humanities received less direct attention in scholarly publishing from an explicit knowledge economy perspective, social science was also evolving a knowledge economy focus as scholars from Brazil, Russia, India and China draw attention to the innovation-inequality conundrum in India (Joseph, Singh & Abraham, 2014) and the innovation system and inequality reduction in China (Liu, Han & Chen, 2014).

In constructing this knowledge economy discourse, the writers have raised a debate, which takes on the proportions of a grand theory. Castells (2000: pp.70–165) has been the most eloquent on the effects of "informational capitalism" on society, discussing how countries in the developing world can be both included and excluded at the same time. Scholarly publication from South Africa and India has reviewed the changing approaches in knowledge production in universities and the broader innovation system (Mashelkar, 2008; Narasimha, 2008; Nichols, 2008; Ratchford & Blanpied, 2008; Segal, 2008; Rongping & Wan,

2008; VijayRaghavan, 2008), however no exploration has been conducted with respect to the changing positioning of universities in emerging knowledge economies towards enhanced research activeness or progression to research intensiveness.

2.3.2 Technology transfer and commercialisation

Technology transfer and commercialisation have been extensively studied and theorised in the industry environment and in the university research environment. Commercialisation of university knowledge was considered a complex endeavour, noting that the path dependency of universities did not include commercialisation before the late 20th century. Rasmussen, Moen and Gulbrandsen (2006) discussed the complexities of shifting from the traditional path of teaching and research to the new path of commercialisation, discussing change from a decadal perspective (two decades of change in four universities of science and technology in the small knowledge-based economies of Finland, Ireland, Norway and Sweden). They reflected on the difficulties of co-ordinating entrepreneurship and traditional university activities.

Despite the complexities and difficulties of university based technology transfer and commercialisation of academically derived research, these practices have been researched for more than two decades and have become increasingly part of the university research programme (Gering, 1990; Siegel, Waldman, Atwater & Link, 2004; Theodorakopoulos, Preciado & Bennett, 2012; Tither, 1990).

2.3.3 Knowledge economies, social and economic exclusion

Castells (1996, 2000: pp.70–165) noted social exclusion as a phenomenon of "informational capitalism", which excludes those individuals and social groups who are unable to access or reproduce information, while Florida (2005: p.14) commented on the mobility of scientists and creative people to globally attractive centres giving rise to "mounting economic inequality, growing class divides and,

eventually, worsening political tension…". Exclusion and inclusion needs to be a much stronger theme in the literature. There is a reasonable literature on this phenomenon, though it is not a particular focus of this thesis.

2.4 Theories and concepts of universities in knowledge economies

The discourse relating to the university in the knowledge economy makes reference to multiple paradigms within which to view the university. These include the 'reason and culture' and 'techno-bureaucratic' archetypes of universities (Barnett, 2000), the second and third academic revolutions, Mode 1 and Mode 2 knowledge, entrepreneurial science, the 'triple helix' of university–industry–government linkages (Etzkowitz, 1990; Etzkowitz, 1998; Leydesdorff, 2000; Leydesdorff & Meyer, 2006), the participation of universities in national innovation systems (Marginson, 2010), and the globalisation of higher education (King, Marginson & Naidoo, 2011, 2013). With respect to research dissemination in particular, historical approaches to intellectual property rights and publishing are contested by open access to knowledge and creative commons licensing approaches (Laakso, Welling, Bukvova et al. 2011; Lessig, 2007). A few of the most widely published concepts and theories are briefly discussed below.

The perspectives discussed here provide the research context, but are not treated as a grand theory, noting that the trends occurring within universities in emerging economies like South Africa and India are not yet extensively researched or well understood.

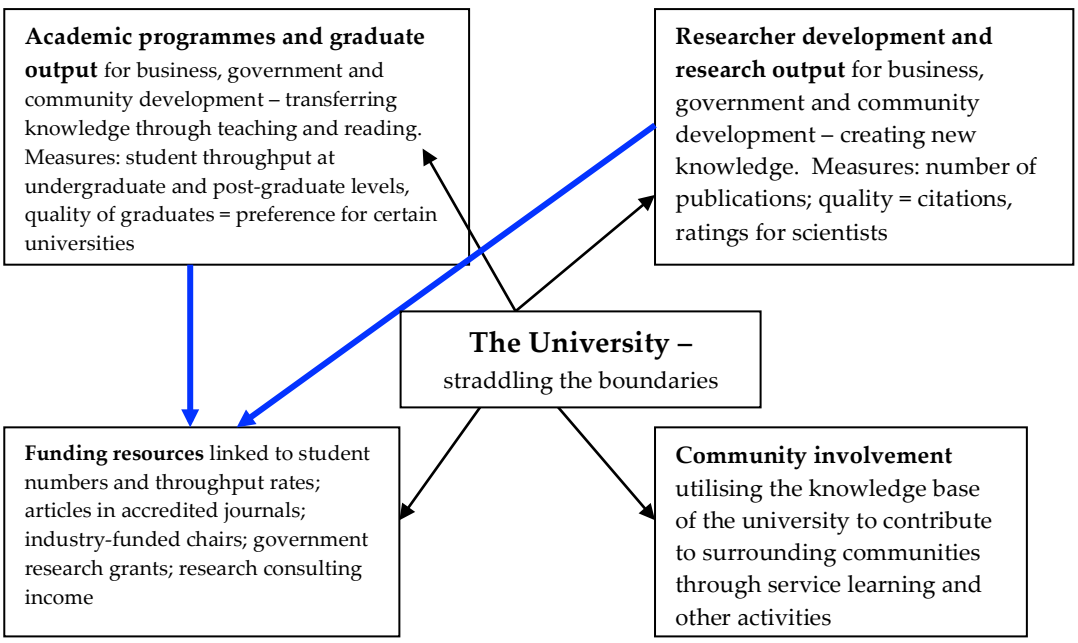
2.4.1 Globalisation of knowledge production: From industrial age to knowledge age university

In the early 20th century, the university moved from being a store of knowledge to producing knowledge goods and services for the mainstream industrial economy. The focus of universities was on academic programmes and research to meet the needs of industrial development, fostering new ideas in the natural

sciences, in the business economics and management disciplines, and in the humanities and social sciences, what Rowland (2005) refers to as "intellectual love and the link between teaching and research".

The industrial age university was founded on two main concepts – the Kantian concept of reason and the Humboldtian idea of culture (Barnett, 2000: p.2). The emphasis was on transferring knowledge to students and achieving high throughput, on conducting and publishing research and publishing the results, with limited interaction with external agencies interested in inventions, patents, licences, prototypes or new commercial goods and services. Research consulting income based on the initiative of particular researchers or heads of research is a recent addition to university funding streams (Barnett, 2000: p.36). Etzkowitz (2002) described two academic revolutions occurring in the 20th century, namely the shift to research-based institutions and the next shift to 'entrepreneurial scientists' and a triple helix of university-industry-government linkages promoting innovation in goods and services.

Figure 2.2 Model of university in an industrial economy



In the mid- to late 20th century, new features began to emerge in the global economy, preparing the way for a major paradigm shift in the operations of economies and societies world-wide; and in the way universities are thought of. Twentieth and twenty-first century knowledge societies and economies have been thought and written about for several decades (Carayannis & Campbell, 2011; Castells, 1996; Houghton & Sheehan, 2000; Perez, 2004; Stehr, 1994), while analysis of science and society has formulated contrasting ideas and philosophies of science (de Santillana, 1961; Popper, 2012; Kuhn, 1962; Feyerabend, 1970; Feyerabend, 1993). University change has been the subject of much research, both in South Africa and abroad (Barnett, 2000; Cloete, Maassen & Moja, 2013; Etzkowitz, 2002; Perez, 1992).

The university became a space for developing human capital – highly skilled, multi-talented, computer-literate, intellectually innovative – for the new economy. University access to the Internet has fuelled the pace of knowledge exchange and afforded greater global research collaboration simply because of the ease of communication and access to information through Internet and broadband communications (Cornford & Pollock, 2003) resulting in digital transformation (Hanna & Qiang, 2010) in the university.

With these external influences at work, the focus of universities shifted from merely transferring existing knowledge through teaching towards the supply of knowledge capital (Etzkowitz, 2002; Etzkowitz, Gebhardt, Webster & Terra, 2000), the supply of people who could design and operate new innovation-based business ventures. In this new environment, measures for success included higher student throughput ratios, high demand for PhD graduates and post-doctoral researchers, multi-disciplinary research programmes and the creation of new bodies of knowledge (inter-disciplines) such as nanotechnology and space science. Governments, faced with competing demands for expenditure, pushed

universities further into entrepreneurial mode (Clark, 1998a), arguing that the private sector should be willing to contribute a greater share of university revenue based on emerging university and business relationships – the demand and supply of human capital and R&D (Melody, 2002). Funding resources were still linked to student numbers and throughput rates, to articles in accredited journals and industry-funded chairs, but increasingly other funding mechanisms such as dedicated government research grants and innovation funds, enterprise and venture capitalists, became key sources of income for the university.

University research output shifted from merely creating new knowledge to include translating knowledge into innovations in the social and natural sciences (Etzkowitz, 2002) and a technological model of the university (Perez, 1992). There was demand for inter-disciplinary research and pre-competitive research as a means to increase the pace of innovation. Given the ease of collaboration engendered by ICT, research networks and virtual research teams have thrived across schools and universities collaborating at high levels of R&D and innovation intensity (Cornford & Pollock, 2003; Hanna & Qiang, 2010). Research management (Bubela & Cornfield, 2010; Georgantzas & Madu, 1990) became a highly sought after skill in order to facilitate opportunities for success and efficient application of limited resources. Measures of quality included citations, numbers of publications in eminent journals, contribution of R&D to commercialisation of innovations and attractiveness of the particular research unit.

A few issues require more detailed examination. Clark (1983) presents a cross-national perspective on higher education, referring to adaptive capacity, basic values, conflict and accommodation. By adaptive capacity is meant "the capacity to add and subtract fields of knowledge and related units without disturbing others", noted by Clark as "the fundamental adaptive mechanism of universities and larger academic systems". He remarks on this type of adaptation as being

that of localized interests, citing also Durkheim's discussions on universities bending and adapting themselves to change in their environments. Clark (1995) advances his project of setting out the landscape of higher education change in the twentieth century, concerned with understanding national systems of higher education, in particular the research-teaching-learning nexus. In Clark (1997), a more directed discussion of adaptive responses relates to organizing for change, in which Clark refers to system level adaptation and university adaptation in conditions where "demands on higher education outrun the capacity to respond" and "knowledge outruns resources". Yet, university-based knowledge producers do adapt – how? To respond to this question, Clark (1998a) proposes five organizational pathways of transformation (i) a strengthened steering core (ii) an extended developmental periphery (iii) a diversified funding base (iv) a stimulated academic heartland (v) an entrepreneurial culture – enabling universities to meet the heightened demands to become more innovative and entrepreneurial. These will be revisited in the theory building discussion.

Birnbaum (1988) points to the existence of many sub-systems and institutional cultures, but does not concentrate his analysis on the specifics of the research sub-system. A contemporaneous review of Birnbaum's (1988) work by Reyes (1990) argues that:

> The central aim is to establish the plausibility of a framework to study the academic organization of colleges and universities. Though the book amply demonstrates the usefulness of the cybernetic model in explaining how colleges work, I am disappointed, not by Birnbaum's work, but by the limited progress we have made in the area of organizational theory in higher education…the systems approach…has conceptual holes…and it's difficult to define for empirical application….Moreover, the systems approach uses basically a structural-functionalist view…Questions that need theoretical speculation include: What is the relationship between the design of work and control within colleges and universities and the nature of the society within which they occur? …The emphasis placed on rules and regulations and other structural processes leads organizational analysts to neglect the more dynamic aspects of colleges and universities.

I have significant resonance with Reyes' view in relation to this particular study, as the focus of this thesis is on positioning for advancement, rather than on the nature and functioning of the research sub-system.

Altbach (1998, p. 356) in a discussion of higher education in the 21st century suggests that the university is likely to survive without revolutionary transformation, but this is contested terrain. It may be that the university will survive, but the research university may not survive. Mohrman, Ma and Baker's (2007) work on key features of the "emerging global model of the research university" argues that the elite universities have more common purpose with each other than with universities in their national systems of higher education; they have a global research focus and practice enhanced by the international mobility of scientist-researchers; they are increasingly research intensive and less teaching intensive; the academics are team-oriented, cross-disciplinary and entrepreneurial; they have "massive and hugely diversified funding streams" to support globally competitive research; they are masters of the triple helix; and they evolve complex mechanisms for research activity (interdisciplinary research and innovation centres, incubator units, patenting, spin-out companies). These features are indicative of university research sub-systems and universities as agencies of knowledge production within the techno-scientific innovation paradigm.

With respect to Britain, Palfreyman and Tapper (2009) discuss, inter alia, the rise of the university research agenda, where universities behave as an industry responding to market dynamics, resulting in organizational fragmentation. Similar dynamics are observable at the South African case study university, for example, the JCSE industry orientation and focus on software innovation, but this does not suggest fragmentation. How does this industry orientation relate to research activeness and the transition to research intensiveness? Theories of globalization in higher education abound, but much of the literature reveals the

local specifics of emerging forms of organization and debates about these organizational developments, as compared to contemplation of the processes underlying knowledge production.

2.4.2 Entrepreneurial universities, entrepreneurial science and the triple helix

The body of research on universities in the post-modern era covers a wide range of paradigms, which includes entrepreneurial universities (Clark, 1998a; Etzkowitz, 2002; Wong, Ho & Singh, 2007), the triple helix of university–industry–government (Etzkowitz & Leydesdorff, 2000) and the tension between universities as a social institution and universities as an industry (Gumport, 2000). Yet other theories of knowledge relating to observed changes in how universities engage with knowledge beyond the boundaries of the university included the theory of mode 1 and mode 2 knowledge (Gibbons, 2000).

Etkowitz and Leydesdorff (2000) introduce the concept of the triple helix of university-industry-government relations as universities structure university-industry-government partnerships to utilise their knowledge capital for mutual benefit for all three groups. The work initiated by Etzkowitz and Leydesdorff has yielded a series of "triple helix" academic conferences presenting multiple studies on the triple helix theory across all continents and across developed and developing countries evoking writing on triple helix formation in countries like Indonesia where cohesiveness of universities, community actors in local economic development are enabling economic problem-solving and dissemination of innovation (Ery Supriyadi, 2012).

Etzkowitz (2002) highlights three academic revolutions, of which the second and third academic revolutions were most pertinent to this research. He argues that the first academic revolution constitutes the transition from the university as a store of knowledge to the university as a creator of knowledge. He asserts that the second academic revolution occurred in the US throughout the period of the 1920's to the 1990's, as increasing numbers of university-based scientists moved

from academic science to "entrepreneurial science", finding markets and generating income from their discoveries, the commercialisation of academic research as compared to firm-based R&D, thrusting universities into an economic and social development mission. He asserts further that the third academic revolution involved the "capitalization of knowledge…the practice of firm formation from academic research assisted by venture capital", which has become widespread in the US (2002: p.4) and gave rise to science-based regional economic development (ibid: pp.78–88). This revolution incorporates the triple helix framework of university-government-industry relationships. He states (Etzkowitz, 2002, p.9):

> The entrepreneurial university is a continuation of the development of a medieval institution for the conservation and transmission of knowledge into a multifaceted institution that also creates new knowledge (*first academic revolution*) and transforms it into practical uses (*second academic revolution*) (author's clarification in italics).

In the US, the second academic revolution was earmarked by examples such as the Alumni Foundation of the University of Wisconsin, which sold patents to industry, thus financing its research development in biology in the 1930s and 1940s and the change in the academic-industry interface from a separation to a cross-fertilisation of academic and commercial practices (Etzkowitz, 2002, p.12-13).

In the past decade, many scholars have added depth to the consideration of the form of entrepreneurial universities discussing how to measure and understand industrially relevant science (Tijssen, 2006), the nature of academic entrepreneurship (Abreu & Grinevich, 2013; Grimaldi, Kenney, Siegel & Wright, 2011; Kenney & Goe, 2004), while Philpott, Dooley, O'Reilly and Lupton (2011) examined the academic tensions inherent in the entrepreneurial university and Styhre and Lind (2010) referred to the "softening bureaucracy" as the entrepreneurial university seeks to externalise itself. The aspect of values systems is taken further in the discussion below.

2.4.3 Values systems and institutional change in universities

This brief overview of the discourse on the changing nature of the values systems held by universities and the related institutional change arose out of the initial 2008 stage of grounded theory research on university values and value in the case study institution. The literature on institutional change is extremely broad and is therefore covered in limited detail, noting that a discussion of institutional change is embedded in the literature on techno-economic paradigms and revolutions discussed above.

Clark (1972) builds a theory of organizational saga to express the bonds and sense of community and inclusiveness built up over generations, for internal and external groups associated with, in this case, three universities. This is the organizational saga of loyalty and community. The value of this theorization is that, as with the perceived value of grounded theory (Kenny & Fourie, 2014), the theory survives for a very long time, even where the context, environment and era changes. But not all organizational sagas in universities are about loyalty, community and shared histories. As Clark suggests, some organizational sagas include exclusion or at least perceptions of exclusion. Using this theory of organizational saga, researchers could create an organizational saga for university positioning. This thesis addresses itself to the emergent strategies in positioning the university with respect to its research activeness or research intensiveness, the part of the cultural life of the institution that is most clearly connected into the broader innovation system.

Clark (2001) focuses on the reinterpretation of historical values, one could say the repurposing of the historical values of collegiality, autonomy and achievement (or success or academic excellence) from an era of management for an era of entrepreneurialism. Central to this article is the question: “How can we, in our setting, position our organisation to best pursue opportunities? And keep, we

might add, the underlying values that characterize universities" (Clark, 2001, p.17). While the question is posed as a general question, and is thus very similar to the research question posed in this thesis, the context for Clark's (2001) question is the transition from the collegial university or the distinctive college with its own organizational saga to the entrepreneurial university. In this thesis, the context for the research question is the complexity encountered when attempting to pursue research activeness and research intensiveness of various kinds, which certainly includes the possibilities of entrepreneurial science, but is not occupied with that particular endeavor alone. Furthermore, in this thesis the elaboration of academic values extends beyond the repurposing of historical values to include additional values. He pursues an extensive discussion on university change and which kinds of universities, under what circumstances, may best adapt to change.

Smith and Webster (1997: pp.1–14) discuss contested visions of higher education noting the broad range of "changing ideas of the university" in Britain and Europe. They summarise the discourse and debate in their edited collection that at one stage in its history, the university had a main unifying theme, namely that of a community of scholars engaged in knowledge transfer and production in a historical context in which there were no competing institutions making knowledge claims; while in the current era it is a set of different types of institutions, characterised by difference both vertically and horizontally within institutions, and is an environment of "mutual contestation of knowledges" (Smith & Webster, p.5). Some authors show that this contestation can have beneficial effects for universities. For example, Gulbrandsen and Smeby argued, based on a study of all university professors in Norway, that industrial funding appears to encourage increased research intensiveness (Gulbrandsen & Smeby, 2005, p.932):

> …they collaborate more with other researchers both in academia and in industry, and they report more scientific publications as well as more frequent entrepreneurial results. There is neither a positive nor negative relationship

> between academic publishing and entrepreneurial outputs.

Similarly, van Looy, Ranga, Callaert, Debackere and Zimmermann (2004) made the claim that entrepreneurial and scientific performance are reciprocal rather than contending forces in academia. However, Olsen (2005) notes the many challenges for the European university, including that actors may have shared or conflicting objectives with respect to university "autonomy", a key concept in the academic values literature. He recognises four main governance perspectives for the European university: a self-governing community of scholars, an instrument for national political agendas, a representative democracy, a service enterprise embedded in competitive markets. He engages with the possibility that any particular university may, at any point in time, occupy all these "positions" simultaneously, with one or another position being dominant. He points to several dilemmas – proliferation of identities, individual freedom, access to resources, renewal and continuity. The most relevant part of this work is the inductive argument that "institutional success may also carry the seeds of institutional confusion, crisis and change" (Olsen, 2005, p. 39):

> Historically, universities have survived by turning institutional confusion and crisis into reexamination, search, innovation and rejuvenation. There is no guarantee it will happen again. Developments will, as before, depend upon many factors the University cannot control. What the University can do is to critically re-examine its self-understanding as an academic institution: its purposes, core values and principles, its organization and governance systems, its resources and friends, and its social obligations.

Howell and Annasingh (2013, p.38) discussed the cultural transformation of the university with respect to knowledge generation and dissemination, noting that internal and external influences can create "a critical juncture … (of) internal and external pressures to develop beyond the original path-dependency". This would mean that universities are not bound to act out their historical trajectory. The most in-depth treatment of such critical junctures was found in Barnett (2000), who argued that the world of the university had become super-complex because it was confronted with a range of metanarratives, (or grand theories or large

stories of the world), which those interest could choose between or attempt to accommodate side by side (2000: pp.75–83). He argued that in a super-complex world of large stories of the university, there might be different large stories for different segments or different functions of the institution. This is an influential idea for this thesis.

Pinheiro, Geschwind and Aarrevaara (2014) observe the prevalence of Olsen's (2007) dilemmas in Nordic countries, (i) internal tensions over matters such as the appropriate balance between equity and excellence (ii) governance arrangements pertaining to centralization versus autonomy (iii) funding and resource matters and their effect on the relative independence and academic freedom of the university mission from external capture and (iv) the interplay between change and continuity and the effects of path dependencies. The article notes a range of tensions and dilemmas, including in the areas of governance, managerialism, funding and financial autonomy, government and regulatory pressures. It argues that these tensions and dilemmas are interconnected in Nordic universities, as previously argued by Olsen (2007) with respect to European universities.

Institutional change theory includes examination of organisational complexity (Gupta, 2006), transforming organisations (Kochan & Useem, 1992), management in the 21st century (Chowdury, 2000) and reshaping the university (Barnett, 2005). The most relevant of these many theories and theoretical toolboxes was the consideration of large-scale change (Kotter & Cohen, 2002, p.1-14), which argued that:

> People change what they do less because they are given an analysis that shifts their thinking than because they are shown a truth that influences their feelings. This is especially so in large-scale change, when you are dealing with new technologies, mergers and acquisitions, restructurings, new strategies, cultural transformation, globalization, and e-business – whether in an entire organization…or a group. In an age of turbulence, when you handle this reality well, you win. Handle it poorly, and it can…cause a lot of pain.

This perspective was influential in the thinking that underlies the research design for this thesis, because of the interest in the intangible aspects of the university shift away from its historical path dependency.

While Barnett writes from a historical view of the evolution of the medieval university to the post-modern university and Etzkowitz writes from the historical view of the American land grant colleges evolving into 'entrepreneurial universities', the common view expressed is of a new university paradigm, no, multiple new paradigms co-existing, from which academics and university managers can choose between or attempt to accommodate more than one. As Barnett states (2000: p.21):

> In this, its post-modern realization, the university lacks specificity; it is a set of possibilities, to be realized or not partly through the fortune presented by the external world. And hence the positioning: we never know what will turn up in the world, so let's be ready for it when it comes. Here, then, we have a glimpse of a new way of understanding the university: no longer a site of knowledge as such but, rather, a site of knowledge possibilities.

Barnett proposes the following six *conditions* for reinventing the university: critical inter-disciplinarity, collective self-scrutiny, purposive renewal, moving borders, engagement and communicative tolerance (2000: pp.103–109). Barnett does not, however, review the university in an emerging economy context, where particular metanarratives are used or have begun to unfold.

Melody (2002: p.9) takes a bold stance and argues that higher education institutions are increasingly being recognised as businesses of a special type and that, rather than shying away from this view, universities should adopt their own business models relevant to the particular nature of their evolving business needs and interactions.

Higher education researchers on other continents echo the analyses documented by Barnett and Etzkowitz. In *Networking Knowledge for Information Societies:*

Institutions and Interventions, Sheehan (2002, p.33) discusses the Australian situation:

> We have barely begun to address the place of the university in the knowledge-based society, where knowledge is at the heart of economic and social affairs and, hence, also the focus of the ambitions of individuals, companies and governments. While trading on the cherished ideal, most universities have developed into quite different institutions, where the pressure of teaching, fundraising, administration, publication and competition make a mockery of the disinterested search for truth … Many of us, at least outside the United States, are struggling within university institutions that have lost their way in the welter of conflicting demands, expectations and vested interests. To sort through these problems, and to preserve some space for the historic ideal, will require both clear thinking and committed action.

Juma, writing from the experience of the African Virtual University (2003, p.207) argues that:

> For sub-Saharan Africa to participate actively in the global economy and to solve its many social, technology and political problems, it has to invest in education in order to build its capabilities in the fields of science, technology and business.

These references and quotations establish some of the key features of higher education in the knowledge economy as fundamental to country competitiveness, as activity in a realm of super-complexity, as a contestation for a new ideal world, and as a necessity for emerging economies and economic regions to grow socially and economically. Universities in South Africa, India and other emerging economies will experience, take on board and do duel with all these features as the external world impacts on the institution without regard for its limits and constraints.

2.4.4 University research and economic development

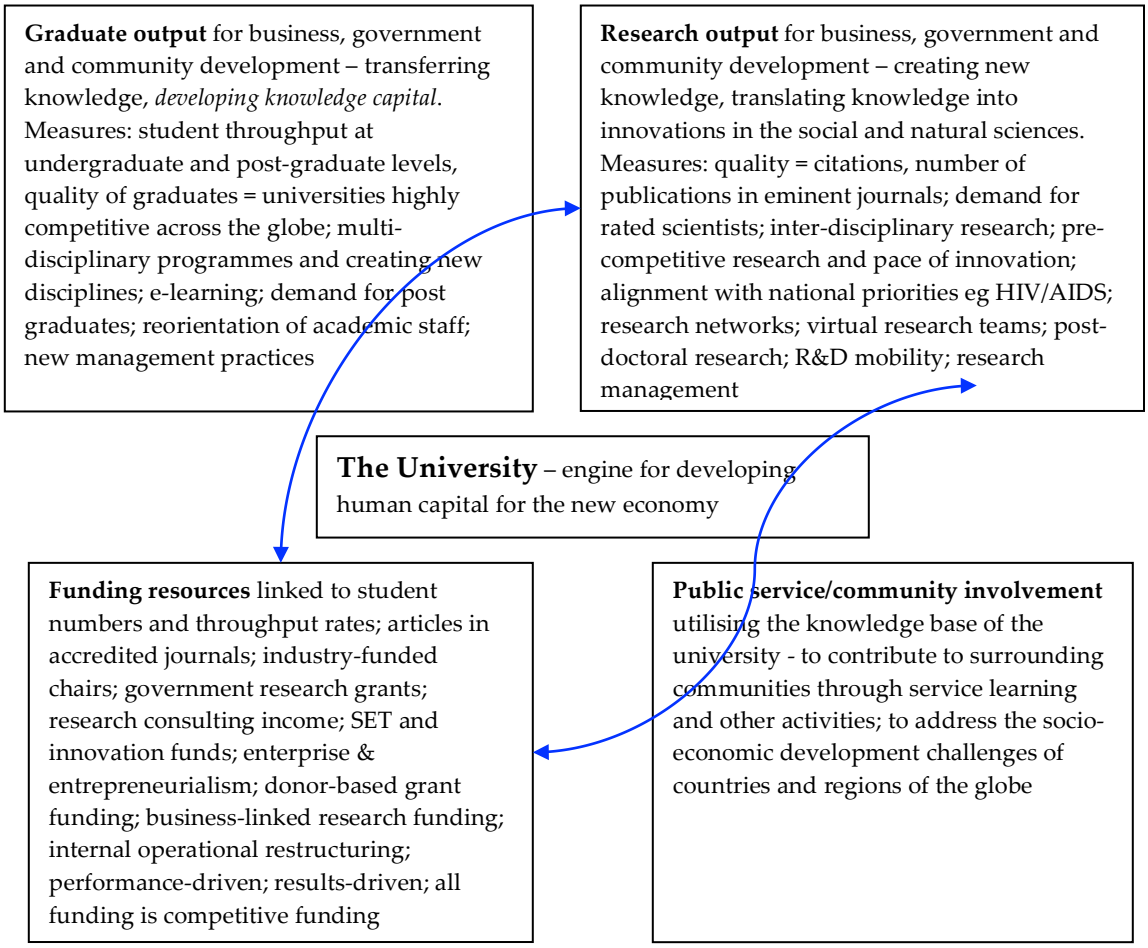
What is the university today? Does 'the university' exist? Many authors have answered the latter question in the negative, arguing that there are many versions of the university (Bauman, 1997: pp.17–26), and that the contemporary university depends on where the institutions are located geographically and

hence also on the historical evolution of the university in that particular context (Marginson, 2010), on their role in science systems (Atkinson & Blanpied, 2008), on their levels of research intensity and knowledge transfer (Hewitt-Dundas, 2012), the creation of spin-out companies (Lockett & Wright, 2005), the knowledge contribution to sustainable development (Sabau, 2010) and the broad role in economic development at national, regional and local levels (von Massow, 1983; Goddard & Vallance, 2013).

Calzonetti, Miller & Reid (2012) offered insights into the role of universities in economic development as supporting industry clusters through forms of technology intensive and technology limited engagement. They argued that "…even a modest sized research University can advance both types of clusters through active cluster management…" (Calzonetti, Miller & Reid, 2012, p.265). Other scholarly research examined the influence of universities in economic development beyond the immediate geographic location of the particular university to its influence in regional economic development (Bramwell & Wolfe, 2008; Reveiu & Dardala, 2013).

Access and social exclusion, race and gender, winning resources versus contributing to knowledge, internal focus versus external focus, quality and relevance, the challenges of academics conducting both teaching and research, disinterested research and public interest research – all are issues that permeate the being of universities. However, these timeless issues must be considered within the context of a new form of the university, as discussed here.

Figure 2.3 Model of changing dimensions of the university in the knowledge economy



2.5 Comment: Universities, national innovation systems and strategic positioning

The literature incorporates a desire for advancement and a cry against the changing times. Why should scholars be surprised that the institution of the university is in flux? As society and economies change, so institutions change and the university cannot remain enraptured with a previous era. Nor does the university have to adopt the stance of follower or agent. The university can morph, redesign and reposition itself in the new societal setting through a variety of processes of adaptive change. Like the fresh water crocodiles of the St Lucia estuary adapting to a salt-water habitat, the university can outrun its demands and resource constraints (Clark, 1997). The question is how does it do so.

The university is already undergoing adaptive change, as set out clearly in the extensive literature. It is the nature of this change and its many dimensions, successful adaptations and mis-planned routes, that is fascinating; that requires discovery and can lead to the explication of a perspective on adaptive change.

The debate with respect to paradigms of higher education change and the role of universities in economic development opens up the opportunity for universities in emerging economies to consider and theorise the positioning of universities in society as spaces for producing knowledge in relation to haunting social, cultural, economic and environmental challenges.

The concept of positioning is taken from Sun Tzu's The Art of War (translation by R L Wing, 1988) – positioning for success (or triumph). Where there is "conflict" in the environment, in other words, where the environment is unfavorable, positioning is necessary. Wing's interpretation is that positioning will advance the capacity for success in unfavorable environments. Many concepts have been used to explore and explain a wide range of aspects of research activity in universities (research ambidexterity, nested tensions, entrepreneurial universities, university technology transfer, research intensity, other), however these are all building blocks for understanding the complex nature of the success of university-based research production. Similarly, the research undertaken here searches for additional building blocks to understand successful university research production, because the full nature of this phenomenon is not yet understood. This work relates to the perspective presented by Mintzberg, Ahlstrand and Lampel (1998) on the "positioning school" or "strategy as analytical process".

2.6 Theoretical framing: Thinking about higher education positioning

The subject of this research is the positioning of universities in emerging knowledge-based economies (in India and South Africa) with respect to their research activeness and research intensiveness. Existing research on universities covers multiple paradigms and concepts. Of these, this study considered the following concepts to be of interest: the notion of super-complexity as the context for institutions, entrepreneurial science, academic revolutions and knowledge helices, techno-economic revolutions and paradigm change, digital transformation, strategic positioning create a canvass for thinking about what enables universities to make the very difficult paradigm shift to enhanced research practice, activeness or intensiveness (Deem, 2001; Etzkowitz, 2002; Mohrman et al 2007).

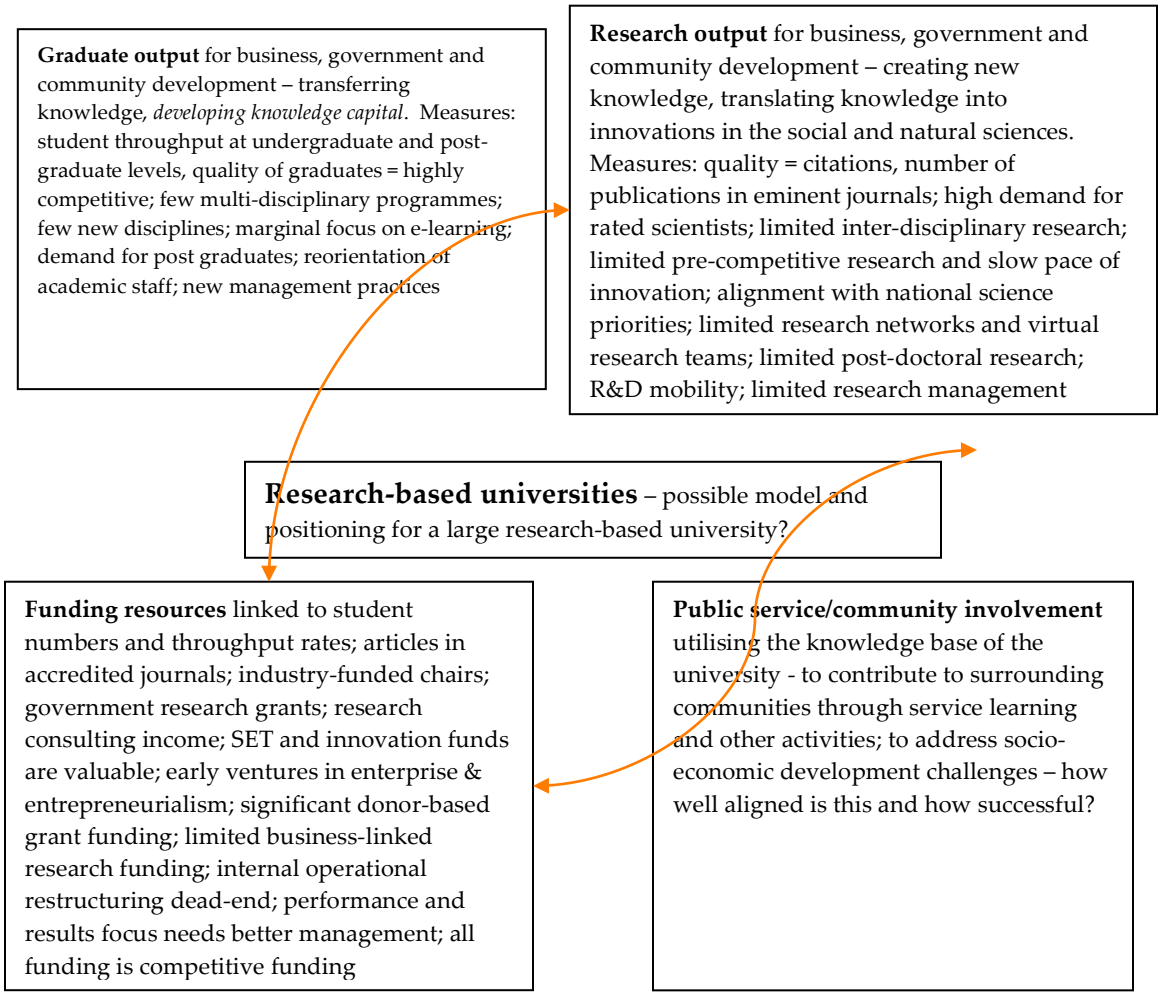
There was an intersection among these (and other) themes from the literature, linked via references to the changing nature of universities and university input-throughput-output in a knowledge economy. Universities that succeed at being entrepreneurial, getting high throughput overall and especially at upper post-graduate levels, contribute most significantly to their country and regional knowledge economies. Based on their success levels, they are able to reap significant benefits in recognition and reward, thus strengthening their financial position.

This research seeks to understand particular underlying features of the university transition in South Africa and India, and thus to fill the gap in current knowledge, by reflecting on the experience of research-based universities in formative knowledge economies. The research design illustrates an awareness of selected theories on universities in the knowledge economy context as referenced above. It was the intention of the researcher to study various aspects of the transitions and institutional strategy of universities, in order to better understand current, latent or emerging themes and trends. It is useful to think about the

research approach as "theory not of literature but as literature" (Rabaté, 2002, p.117).

The thinking model for this grounded theory study, based on the theoretical framing outlined above is presented in Figure 2.4 below:

Figure 2.4: Thinking model of changing dimensions of the university in the new economy



This diagrammatic representation of universities in 21st century knowledge economies draws to a close the discussion on the guiding theoretical ideas for the study, noting that the study intends to explore the positioning of universities beyond the realm of this theoretical background, as existing theory does not

explain the theory of the positioning of universities for greater research activeness. Taking note of the advances discussed in the literature, the investigation in South Africa and India can contribute to the search for paradigms and theories of understanding how and why universities in knowledge economies characterised by low or medium knowledge and technology intensity achieve the transition to research activeness and intensiveness.

2.7 Methodological issues arising from the literature review

As the analytical process for building grounded theory evolved, a review of literature on theories of institutional change was consulted, with particular interest in the following view (Feyerabend, 1993: p.215):

> In all these cases, we have a practice, or a tradition, we have certain influences upon it, emerging from another practice or tradition and we observe a change. The change may lead to a slight modification of the original practice, it may eliminate it, it may result in a tradition that barely resembles either of the interacting elements.

This quotation has bearing on counter-inductive analysis, as it directed the researcher to look for the less obvious ideas about the subject, or ideas, which were in opposition to those arising from inductive analysis.

What is methodologically relevant about Clark's work is how theories are formulated from data gathered through case studies in several components of his body of work. He develops the theory of organizational saga using what is effectively grounded theory methodology. While he does not use the words grounded theory, Clark specifically states that he is theorizing from data obtained from observation, not building on previous theory. There are various methodological similarities for the thesis with the work of Clark (1972; 1998a), as Clark (i) is investigating particular aspects of transitions in higher education and (ii) uses grounded theory methodology. It is noted that Clark's study on the five organizational pathways of transformation referred to above was developed from case studies conducted at five European universities. He says (Clark, 1998b,

p. 2):

> I treated each university as a case study of institutional change, with its own uniquenesses and peculiarities. But as the research proceeded I was also able to tease out some elements of change that these five universities, variously located, had in common. I came to call these elements "pathways of transformation"; and was able to use them to frame the case studies. The study allowed me to interact closely with the institutions I was studying, in a rich and rewarding way that I had not experienced before. "Practitioners" were my teachers; "practice" rather than prior "theory" was the basis for my results.

Deem (2001) critiques Clark's (1998a) work, questioning the absence of a stated grounded theory methodology and asking to what extent the results may have been pasted on to an a priori framework.

This study took a deliberate and expressly articulated grounded theory approach. This study follows an analytical process of data coding as the basis for theory generation, it does not use conventional qualitative data analysis (QDA). One key difference between this thesis and the work of Clark is that Clark progressively sketches particular features of the higher education landscape and higher education change through his many works. The particular feature addressed in this thesis, namely the sidetrack of academic actors and institutions pushing through adversity in the research game in search or research activeness or intensiveness, is not examined in Clark's body of work in any depth, apart from the discussions on entrepreneurial universities.

Chapter 3 Epistemological and methodological stances: Social constructionism and grounded theory: Seeing dimensions of the lived experience of research activeness

The subject of this research is the strategic positioning of universities in emerging knowledge economies with respect to their research activeness and research intensiveness. This chapter maps out the epistemological stance taken and the methodological approach applied during the research undertaking. The study is social constructionist with respect to its design and postmodern critical theory with respect to its objectives.

The research problem in this thesis is a theoretical problem "how universities advance through research activeness to research intensiveness" that needs to be understood in order to provide a basis for strategic positioning. This is the type of problem that requires qualitative research, because there is no single or direct "answer" to this research problem and the problem is not one that requires quantification.

3.1 Research philosophy: Epistemological and ontological stances

From the applicable epistemological approaches generally taken in qualitative research, the researcher adopts the stance of social constructionism in "human inquiry", noting Schwandt's discussion that data and knowledge claims are not located solely within a "realist view of representation" (Schwandt, 2003, p. 197). The rationale for social constructionism in this thesis is that it permits the researcher to "see" into the evolution of the university research sub-system, at least those parts made visible in this research; to gather up experiences, perceptions, insights and ideas through the narrative presented in documents and in interview-conversations; to review, consider and examine these; to aim at an understanding of the research problem; to gradually chart the contours of the research problem and to present an impressionistic view of the world of the

problem, alive in its environment. The research problem is alive (evolving) rather than real, meaning that we can grasp at the sense of it, we can theorise it in order to understand it, because, in the qualitative social constructionist sense, theory is impressionistic rather than real.

The approach of social constructionism is made manifest, in the case study and theory building chapters, through extracting and drawing out a new narrative from the documents, a new narrative from the respondents, contemplating the language of documents and the language of respondents, drawing the impressions into a version of events and experiences, building the coding system by reading into the meaning of words and the content of documents and conversations. The coding forms steps in deconstructing the meaning of lived experience and insights into what researchers are doing, and what they say about what they are doing. The coding creates spaces for extracting and making explicit those elements that will constitute theory, whether as themes or categories or sub-categories. In constructing the theory with these elements, the work gives rise to theory grounded in the data.

From the epistemological stance of social constructionism, we need not view data as "representative", but rather as purposeful and meaningful. This data is purposeful in that the data provides (i) specific conceptualisations of what scientists are doing (ii) insight into the environment within which the doing occurs (iii) insight into features and characteristics of the research sub-system (iv) the material to be processed which will reveal the opportunity for theory building. From my perspective the narrative is the data, in the sense that there is no data that is separable from the narrative – it is the narrative containing data that reveals or discloses meaning. This data is meaningful in that the narrative, whether documentary or spoken word, constituted from extracts of both and pieced together, reveals layers of possible ways of understanding the particular phenomenon being studied. These layers can be examined through a coding

process, making explicit what is implicit. Coding enables theorisation, whereas the narrative alone does not. In these case studies, coding performs the role of analytical action on the narrative/data. While limited qualitative commentary on the data is included in each case study, detailed qualitative data analysis is not required for grounded theory building. The coding operates to stay as close to the narrative as possible using inductive analysis, departing from the narrative only to consider the counter-inductive options available to the researcher.

Thus, in this thesis, epistemologically speaking, we come to know some ways in which scientists and other research actors can sustain and grow their research activeness and transition to research intensiveness, because a range of data has been drawn from particular distinct narratives into a formative narrative, then particular instances that draw meaning from the formative narrative and give meaning to the theory building process are coded and categorised, selected and moulded into the theoretical proposition. The "formative narrative" is postulated not as a metanarrative or grand narrative, but rather as a way of combining key features of parallel narratives.

The implication of this epistemological approach for the ontological stance of the researcher is that we are dealing here with disclosure of meaning of the lived experience, rather than a representation of the real world. The concern is not what "is", but what actors "are doing", and what they "think about what they are doing".

The problem design, purpose design and methodological design, all draw on postmodern critical theory in one particular respect, namely that the interest of the researcher is seeing into universities, from a knowledge economy world-view, searching for a perspective other than that of the dominant practices and theories on the subject. Furthermore, the purpose of knowing is not to know, the purpose of theorising is not to extemporise, the purpose of knowledge gained in

this study is to find sufficient insight to project how similar actors and agencies may derive knowledge that could be applied through strategies of institutional positioning.

The combination of the specific social constructionism and critical theory stances taken here leads to the methodological stance of grounded theory and the methods of grounded theory case studies. Five case studies are presented – research challenges in the university research sub-system with respect to research active universities in India, the evolution of a nascent technology (tech) hub; the evolution of a rural knowledge facility; the evolution of intellectual property rights policy and practice; and the evolution of open access intellectual property approaches in scholarly publishing, the last four drawing on the South African case study university.

The epistemological stance evolves over the period of the research, from the initial stance adopted in preparation for the research (universities in the knowledge economy) to the evolving thinking during the research (university research sub-system) to the thinking in the final stages of the research (research activeness and research intensiveness). The researcher is interested in the idea of knowledge economies, because this is the context within which research activeness and research intensiveness are raised for discussion, even where the very groups engaged in the discussion may not have a clear conceptualisation of universities as "knowledge economy institutions" and may not locate the discussion of research activeness and intensiveness in that broader context.

To which kinds of institutions would this work be of interest and/or significance? In the final stage of the research, one particular set of institutions emerged as relevant, namely the set of formative technology hubs, of which there are an estimated 90 on the African continent. This research and theory building would be of interest and significance to these technology hubs because their survival

and growth rests on the ability to design and effect strategies that lead to increasing research activeness and research intensiveness.

3.1.1 Reflections on postmodernism and the researcher

Reading Carspecken and MacGillivray (1998), the researcher is invited to be an insider, when the research novice is often defined as an outsider. The world of research often defines the non-researcher or the inexperienced researcher as the other, as needing to be kept at bay – perhaps for lack of familiarity with the tools of research. Carspecken and MacGillivray break that paradigm. They suggest that each new research project is a new beginning, an opportunity to explore not only the subject or substance of the research, but also the research methodology. They reflect on their subject, just as they introduce the subject of reflection to the reader. As such, they provide an insight to the value of post-modern thought as applied to research, namely that we can all simultaneously interpret and construct a view of the world or the research subject and make explicit our views and interpretations in our own way. This approach is appealing as it immediately unlocks knowledge from the traditional boxes of research methodology. Furthermore, Glaser (2009b) articulates possible advantages for the novice grounded theory researcher, as being open to conceptualisation of categories and codes because they are not yet strongly influenced by the long-term practice of other qualitative methodologies. Cruk, Pakulski and Waters (1992) take the reader beyond questioning to self-questioning, suggesting the importance of inductive and counter-inductive analysis. These points are expanded in a later section of this chapter.

3.1.2 Reflections on postmodern critical theory: Marx, Kuhn and Foucault in fast forward

A key theme in the readings on the context within which research occurs is how the subject is positioned in research. The existence of universally applicable knowledge, as meant by the universal application of some set of standards that

applies to all circumstances irrespective of cultural, economic or social circumstances and belief systems, and the notion of objective truth has been called into question by many authors, including Marx (1846), Kuhn (1962) and Foucault (1969). Each of the protagonists attempted to stand something on its head – Marx wanted to stand Hegelianism on its head, Kuhn deconstructed the notion of a paradigm and its role in research, while Foucault challenged the notion of universally applicable truth. They attempted to fast forward the researcher into a world where everything was open to question, including the rules of the research game.

Marx (1846) developed Hegel's dialectic (thesis creates its own antithesis and the two in conflict gives rise to a new construct) into dialectical materialism (reinterpreting society through the lens of class struggle and its role in social change). He presented an analysis, critique and explanation of the evolution of economic eras through feudalism to capitalism and a vision of socialism. Marx's writings do not foresee the era of late capitalism or the formation of knowledge-based economies.

Kuhn (1962) charted ideas on how paradigms form, fall away and are replaced by other paradigms. Most importantly, he argued that scientists/researchers do not necessarily exercise reason or behave rationally in the pursuit of scientific truth. He contended that paradigms emerged because scientists/researchers sought answers or models based on a formulaic response that best fit all the available data, a regulatory framework of logic that a particular community of researchers/practitioners could use and build on. He pointed out that in so doing, theoretical paradigms became little more than organizing conceptual frameworks that could have explanatory value only until such time as their objective truth was challenged by data that defied the conceptual framework. Old and new paradigms were conceptualised to be constantly doing battle with each other, until a new paradigm(s) emerged as hegemonic for a time.

Foucault (1969) provided a critique of how the subject was treated in research. He further interrogated the question of how research was used to create an organising framework with which the subject must comply. Foucault's observation that knowledge statements often seek to comply with pre-existing rules draws the researcher's attention to the point that research design can be restrictive, where it forces thinking about the research subject to remain within the constraints of the rules. By implication, the discourse suffers from the limitations placed upon it and consequently limits the knowledge that can be gained within a particular discourse. Hence it is necessary to construct the research context to break the rules of the given discourse, in making knowledge claims that advance knowledge of the world. From this perspective, grounded theory is a methodology that provides an alternative to forcing research into narrow confines, which Glaser (2013) refers to as "staying open" to conceptualisation.

The relevance of this discussion for the research study is that the range of theories pertaining to knowledge economies (knowledge globalisation and internationalisation, marketisation of academic research, entrepreneurial science and the triple helix of knowledge production, other), present themselves in the realm of grand theory. However, authors such as Smith (2002) contest the notion of grand theories of the knowledge economy, breaking the rules of the discourse by questioning what is defined as being included or excluded from this theoretical construct. This contestation around grand theories of knowledge economies suggests the need to adopt an open-minded approach to the research subject, to ask questions about the paradigm, the rules of the discourse, and to use this questioning to explore new knowledge claims.

This thesis is situated within the broad context of the discourse on universities in knowledge economies, noting that universities, in particular their research sub-systems can also be located within the theoretical conceptualisation of national

systems of innovation. This raises a few options for setting the theoretical framework for the study (i) the study uses the broad parameters of the discourses of "universities in knowledge economies" and "national systems of innovation" to guide the research study and questions, while questioning the roots and direction of the discourse as applied in the particular study, and through study and analysis searches for new or emerging paradigms and new meaning; (ii) the study deliberately applies the discourse of national innovation systems to the university research sub-system. Here, a number of issues arise from the perspective of postmodern critical theory (Foucault, 1969). I would have preferred to apply the latter approach (ii), but was advised to apply the former approach (i). There are advances in the theorisation of innovation approaches that are not extensively dealt with in chapter two – this is an acknowledged limitation of the thesis. It is my contention that, as a grounded theory study, the work must focus more directly on the data and less on attempting to put its arms around any particular subset(s) of the vast literature on universities in knowledge economies and national innovation systems, though the researcher is of course engaged with the wide body of literature and functions within the innovation and university research environments.

One further problematic that is relevant here is the discussion of the purpose of generating knowledge from this thesis. The researcher adopts the stance of postmodern critical theorist in that the aim is to consider the hidden interests, structures and opportunities that exist, to think and analyse beyond the obvious, to advance a broad theory applicable to a particular part of society and to argue that the theory contributes to understanding the strategic positioning of universities with respect to their research activeness or research intensiveness. The aim is to seek knowledge that may be contemplated and applied, though not to arrive at an objective reality or truth. The thesis addresses the importance of strategic positioning and is interested in how strategic positioning occurs, but does not propose a strategy.

3.1.3 Philosophical assumptions: Epistemological, ontological, axiological and rhetorical: From vagueness to enlightenment

The researcher commences the study in a state of vagueness, because the subject is amorphous. As the interactions with the subject of the research intensify, enlightenment emerges as a consequence of engaging with researchers and scientists in creating the case study and applying grounded theory coding techniques. The researcher considers social theory to be an evolving body of knowledge, which is made meaningful in its application to research problems, focusing on adaptations of the applicable social theory approaches to the particular research problem. The epistemological stance, discussed in detail in the previous section, is clearly framed in a qualitative research paradigm, in which "the researcher interacts with that being researched" (Creswell, p.5). In conducting the study, the following epistemological questions guide the researcher: What is the nature of the subject being studied, what are its many facets, and which of these facets can be studied for thesis purposes? These questions continuously inform the research design and data collection.

With respect to creating university research activeness and intensiveness, the implications of social constructionism for the ontological assumptions of this thesis is that the findings and theory do not present an objective reality, singular and apart from the researcher (Schwandt, 2003). The research attempts to map the contours of the subject and the research findings are understood within the context of a changing societal and higher education landscape. The findings and theory are subjective, impressionistic, offering multiple views on the subject, gained from the participants in the study and the engaged researcher (Creswell, p.5). Impressions from multiple sources build into a fabric of impressions, with layers of perspectives co-existing and interacting. While each of the layers may be individually interesting, the thesis is concerned with the synthesis layer, not the individual layers. The theory is a synthesis, not a theory of aggregates.

With respect to axiological assumptions (Leedy & Ormrod, 2001), there is a risk that the way in which the data is presented and analysed may be value-laden and moulded to the bias of the author. This risk was managed by (i) keeping the narrative as close to the language and meaning of the key informants as possible and (ii) making the coding of the data explicit in the case study chapters in order to limit author's bias as the author's interpretation is visible to the reader.

With respect to rhetorical assumptions (Leedy & Ormrod, 2001), the research design followed an informal path, following evolving decisions and events, giving personal voice to the stories of key informants and to the author's rendition. The data analysis followed an inductive process and counter-inductive process, with asymmetrical shaping of the analysis using categories identified during the data collection process. The research design was context bound, searching for patterns and ideas to enable a theorisation relevant to university research activeness and intensiveness. This approach promoted a limited, but nevertheless important understanding of defined aspects of university change.

3.2 Map of methodology and methodological stance

The starting point for the methodological considerations was "what" to study. The research investigation commenced with an interest in the nature of the university in the early 21st century knowledge economy, but it was soon clear that this would offer a great many perspectives. Early observation of the practice of SET research in South African universities, briefly included in chapter one, and early observation at Wits University, the case study institution, suggested that universities experienced significant difficulty in becoming and remaining research active, and in transitioning from research activeness to research intensiveness. Bunting, Sheppard, Cloete, and Belding (2010) confirms that the case study institution, while being one of a few high performing universities in South Africa, does not meet the criteria for being considered research intensive. The literature from India and discussion with an Indian academic suggested that

India had already contemplated this particular challenge within the university system broadly, under the guidance of the work of the National Knowledge Commission (discussed in chapter one). Furthermore, this challenge had been contemplated and acted on by scientists in a particular cohort of universities, namely the research-performing universities and Indian institutes of technology. These threads of observation led to a particular narrower track for illumination, namely understanding the ways in which scientists and institutions move from being research active to being research intensive, whatever the objectives may be – industry-oriented innovation, society-oriented innovation, a combination of the two. The research seeks to understand what researchers and scientists (actors) are doing, what they say about what they are doing, how they explain what they are doing, under what circumstances, why they succeed or fail, advance or stumble.

Turning to the broad literature on research and innovation in universities, many authors deal with the conditions under which scientists (actors) produce or under which universities (institutions) produce (national innovation systems, regional innovation systems, local innovation, types of innovation production, innovation policy, enabling conditions, innovation financing, nested tensions and interwoven dilemmas, other), but fewer authors explained how scientists and other research actors (individual or institutional) persevere in seeking goals and achievements, despite disabling conditions. Research by Etzkowitz, Etzkowitz and Leydesdorff, and others writing on entrepreneurial science (referenced extensively in the literature review), examined the entrepreneurial behaviour of scientists, explaining success and industry engagement as a result of the application of entrepreneurial thinking and doing. But what was the nature of this entrepreneurialism? Were all favourable research outcomes a result of such entrepreneurialism? Does entrepreneurialism fit the needs of universities in developing countries who are seeking to sustain their research activeness or transition to research intensiveness? Is entrepreneurialism such a powerful explanatory mechanism that it should dominate the discourse of research

activeness and intensiveness? Certainly, entrepreneurial science approaches played a major role in building research active universities at places like MIT, Stanford and other industry-linked universities across the world. But is this the only possible path to sustain research activeness and to foster research intensiveness? These ontological questions drove the research design, contemplating the nature of "becoming" research active or research intensive, rather than the nature of "reality".

The exploratory study of India was an important foundational research platform for the research design and for the South African component of the study. The main limitation here is that there could not a more extensive study of central universities and institutions of national importance in India.

The next question for formulating the qualitative methodology was "how" to study this phenomenon. A key methodological challenge is how to generate theory from investigation of a particular research problem. In the thematic area of the transition from research activeness to research intensiveness in university research sub-systems in knowledge economy settings, theory building is at a relatively early stage of development and the ideas pertaining to this early stage have been dominated by trends emerging from universities in high-income services-based economies. Grounded theory methodology enables theory building. Noting the extensive work on outlining the characteristics and utilisation of grounded theory (Christiansen, 2007; Glaser, 2002; Glaser, 2009a; Glaser 2009b; Glaser 2013; Holton, 2010; Kenny & Fourie, 2014), it is understood that grounded theory starts with collecting data on the substantive area, and can include analysis of secondary data, observations, participations and interviews, followed by a review of relevant literature (Kenny & Fourie, 2014).

Data analysis uses open coding and the writing of theory memos and method memos, in order to clarify the means of arriving at the theory and to generate

substantive theory. Several rounds of data collection and coding, along emerging themes or focus areas, is followed by identification of a core category(ies) and main concern(s), which in turn is followed by selective coding with respect to the core category(ies). As the iterative process develops, theory begins to emerge through the coding process, highlighting those ideas that constitute elements of the theory (Holton, 2010). As theory takes shape and definition, theoretical sampling is conducted to reach saturation point with respect to the data and analysis required to build the grounded theory (Glaser, 2002). Given the nature of grounded theory methodology as theory building, this research design does not need to be located in a well defined theoretical framework (Christiansen, 2007), though a few guiding points are set out in chapter two.

The study focused on actions occurring at the level of researchers and institutions, not at the inter-personal level. Insight into the specific institutional transitions (not institution-wide transitions) was gained by looking for typifications through participant observation and document analysis, complemented by interviews. Interviews and document analysis were complementary, in other words they carried equal weight because each was a reflection of the specific dynamics at play. The rationale was that discussing events, processes, typifications and trends could enable the key informants to comment reflectively on their actions and consider why certain trends were appearing and what alternative approaches were probable. This method was used to bring out different views, in particular with respect to the contestation between science for economy and science for society, and with respect to the continually shifting landscape for university-based research. The data acquired was structured into a narrative with coding occurring as the data was processed, building and extracting/constructing meaning through the coding process.

The purpose of this methodological approach was to first map the observable trends, then to consider the applicable metaphor(s) or tropes. The approach

combined well with the philosophical view of social science research as constructing an impression of the phenomenon under investigation (social constructionism), and as an enabler of transformative action (critical theory) with respect to strategic positioning.

Given the above discussion, it is argued that the epistemological stance of social constructionism and the methodological stance of grounded theory provides for a rational form of engagement with the subject, a rationale engagement with the pursuit of knowledge production at high rates. As already stated, coding provides a means to build understanding and also provides the basis for definition of the attributes of the final theory. Coding enables the researcher to select data, and to contemplate and give meaning to the content of documentary data sources in the following ways (i) there are no pre-prepared or pre-conceived codes, however, based on prior knowledge of the subject matter of university research activeness and university research intensiveness, the researcher recognises particular content that relates to the subject, in particular to the research problem, the research purpose and the research sub-questions. As the process of coding the data from documentary sources proceeds, a particular perspective begins to emerge, notably that the documents do not themselves explain *how* researchers become research active, how they grow their research efforts or how their programmes and efforts move towards research intensive outcomes. It is observed that many entities in research active universities in India and many entities in the South African case study institution exhibit high levels of research performance, but it is not apparent why these researchers are highly productive, where the general academic population is considerably less research productive. One logical reason for greater research productiveness is access to and effective utilisation of research funding, but why do some researchers become highly funded and others not? These concerns became pertinent during the early observation phase at Wits University (2007 and earlier, before

commencement of the study) and in the case study conducted with research active universities and institutes of technology in India.

Coding also enables the researcher to select data from, and to contemplate and give meaning to the content of interviews conducted with respondents by (i) creating the means to organise the data and (ii) creating the means to relate the various categories and sub-categories of data in order to build themes and identify the core category.

3.3 Research methods for grounded theory

The grounded theory methodology incorporated successive phases of data collection of participant observation, document review and interviews with key informants. Data analysis was structured according to the coding approaches advised by grounded theorists (Andrews, Higgins, Andrews & Lalor, 2012; Charmaz, 2005; Glaser, 2002; Glaser, 2011; Glaser, 2013; Holton, 2010), while the theory was constructed over time through inductive and counter-inductive analysis with respect to key themes. When using grounded theory, the methodology section is one of the most important sections of the research paper, because the quality of the research design influences the capacity to formulate new theory. According to Leedy and Ormrod (2001, p.154):

> a grounded theory study is the one that is least likely to begin from a particular theoretical framework. On the contrary, the major purpose of a grounded theory approach is to begin with the data and use them to develop a theory.

The grounded theory process for this thesis commenced with the exploratory study of research active universities and institutes of technology in India, as a way of seeing beyond existing theory, seeking the opportunity to theorise based on data from a location that lies outside the scope of much of the theory about universities discussed in the literature review above. The findings from this exploratory study revealed that Indian universities and the broader higher and technical education sector are experiencing major shifts with respect to defining

research objectives as a core component of the university mandate. In particular, broad themes pertaining to positioning universities for greater research activeness were derived from this data using inductive reasoning. These themes included complexity, adversity, curiosity and strategic interest, but the themes were too generic and vague to provide a core category for theory building (Glaser, 2002, Holton, 2010). The Indian data and analysis were used to guide the next stage of research design, which explored the particular attributes of complexity, adversity, curiosity and strategic interest in an institutional overview and in-depth study of a single case study institution in South Africa.

Thus, the research design is a qualitative design, specifically, a grounded theory methodology, applied through an institutional case study, utilising the data collected to construct a theoretical perspective that may be of interest, significance and relevance to universities in emerging knowledge economies.

Using a case study method only could lead to making positivist or empiricist claims, while introducing grounded theory analytical techniques enabled the researcher to consider and develop categories and themes that were not simplistically deduced from the data, but more carefully built up through elaborating complex ideas about the subject matter over time. The case study method was exploratory, gathering perspectives, thoughts and insights from participants in the university system, rather than from scholarly writing on the system.

While the absence of a highly structured theoretical framework to inform the research design may be regarded as a problem, this apparent problem has been addressed in two ways: (i) by acknowledging the broad discourse pertaining to the context in which the subject matter sits and (ii) by commenting on the historical literature in the final chapters of the thesis to discuss how the grounded

theory arising from the case study enriches perspectives already prevalent in the literature.

Grounded theory is both a method of inquiry and a product of inquiry (Charmaz, 2005, p.507). Feyerabend (1993) directs our attention to how to look for change, which can then be theorised. The strategy of inquiry was to write up responses and descriptions of particular events, processes, views and responses pertaining to the period 2003 to 2013 and to ground the concepts applicable to a large research active university as the study proceeds. These concepts were agglomerated into a picture of the phenomenon as a whole, using inductive reasoning (Babbie & Mouton, 2001). Using the data collected, key questions and lines of analysis were drawn from the individual events and from the integrated perspective of the informants. The four procedures for data analysis with respect to grounded theory, namely open coding [designing common categories and themes], axial coding [liberating interconnections among categories and themes], selective coding [creating the story line] and theory development were applied (Leedy & Ormrod, 2001, p.155). Counter-inductive reasoning was used to consider alternative categories or sub-categories, in order to blend conceptualisations arising from inductive and counter-inductive analysis into a theory of university positioning in emerging knowledge economies.

3.4 Application of case study method: Exploratory and main components

Given the limitations of studying a large number of universities, the scope of the study was delimited to a selection of research-active universities and related institutions in India and a case study of a single, large research active university in South Africa. Given the size of these institutions and the range of subject matter available for investigation, the study was further delimited to five in-depth case studies and an institutional overview of the South African case study institution, in order to obtain a depth of insight into the activities, thinking, strategies and shifts within an institutional setting, rather than a diverse set of

cases across multiple institutions, which may not reveal the deeper institutional trends, issues, barriers, failures and transitions.

Since the study sought to understand what changes were occurring in the environment of large research active universities, engagements were followed through a number of events, key informants and lines of enquiry. For the India exploratory perspective, engagements were followed through from the AICTE (All India Council for Technical Education) conference, document and website review, to interviews with key informants (see Appendices E and F), based on the guidance of the first key informant, progressively building a view of institutional trends in large research active universities in India.

The review conducted in Indian higher education institutions sought to understand what shifts were occurring in the research space. The key informants' views, explanations and insights were studied and participants were engaged with the study to share and reflect on their experiences and to build an understanding of how a university positions itself to contribute to and benefit from shifts in approaches to knowledge production. While it was necessary for the purpose of the study to understand how the participants saw the university, its challenges, constraints and opportunities, as well as their own actions, the data represents only substantial fragments of the full picture.

It was noted that the researcher is required to generate the "core category" and the "beginning theory", with "original completeness", rather than extensive theorisation (Glaser, 2012). Alborzi, Khayyer and Johnston (2008) and Gatin (2013) were used to guide this author on possible formats for writing up the final theory statement.

Moving forward from the exploratory case study (India), which identified possible categories or sub-categories or concepts for theory building, the

qualitative research uses a case study design, comprised of an institutional overview and four in-depth case studies, to identify patterns and themes and to develop explanations (Creswell, 1994; Yin, 1994). The case study method is applicable because the research aims to understand how researchers and the institution sees itself, in relation to the questions posed above, from the perspective of the many people participating in the university context and documents, which reflect a range of perspectives. Due to use of the grounded theory approach, the case study does not compare "results with patterns predicted from theory or the literature" (Creswell, 1994, p.156).

The scope of the institutional case study of Wits University set out to cover three broad thematic fields: university-based research; human capital as a factor in the changing nature of the university; and 21st century knowledge partnerships, but remained open to any phenomenon that would inform theory building. Furthermore, the research investigated Wits strategy and institutional memes that linked the institution with its social and economic context, in order to create a narrative of data extracted from the views and perspectives of academics and university administrators and from university documents.

The case study component of the research design incorporated a review of relevant university documents in order to sketch the historical context of the institution being studied and key elements of institutional shaping. In this grounded theory study, data collection, data analysis and thematisation followed each other through a series of events, including (i) an exploratory study of universities, institutes of technology and university related agencies in India; (ii) Wits university annual leadership Lekgotla 2007 and meetings of university leadership; (iii) a study of transition and growth in software engineering; (iv) a study theorising values and value of university knowledge production in a rural environment; (v) a study on research, commercialisation and (vi) a study on open access publishing. Through these events and the case studies that unfolded,

insights were gained on the nature of the research paradigm change. Thus, the theory derived by inductive and counter-inductive means emerged through the process of piecing together pictures read from the data and analysis leading to the formulation of trends and tropes.

The research sought to gather responses to the questions posed (exemplar interview guides in Appendix 1; Appendix 3) from the perspective of people participating in the university context as it intersects with the economic innovation and societal contexts. As such, the data collected includes the views, perspectives and voices of key informants required in grounded theory research (Babbie & Mouton, 2001), namely the researchers and scientists, partners and policy-makers who create the life of the university institution, based on in-depth interviews and writing up perspectives from discussions in meetings gained through participant-observation. Interviews were held with approximately 30 key informants from the university sector in India and from the case study institution, Wits University. The in-depth interviews sought to uncover how academics and university administrators thought about various dimensions and trends in the institution and in the sector. Semi-structured interviews used open-ended questions aimed at hearing the story of the research active university from the perspective of the key informant. The interviews supplemented detailed document analysis, website review, observation and participant observation. Ethical clearance was approved and the requirements of anonymity and confidentiality were complied with.

3.5 Research process: Data collection and data analysis methods

In commencing the research with respect to the research sub-questions outlined above, selected texts including strategy documents and annual research reports, as well as environmental scanning, were used to identify disciplines or schools or academics where in-depth interviews could be sought. Identification of the research instances and the participants for the study arose out of the researcher's

engagement in processes as a participant observer and as researcher. It should be noted that the researcher participates in university-based activities that are relevant to the theme of the research. In-depth interviews took place in Delhi, Gurgaon, Johannesburg, Acornhoek, and Agincourt, Bushbuckridge. Key headings and questions encouraged semi-structured, interactive interviews or open-ended conversations with key informants (see Appendix F).

Document analysis was conducted, gathering a wide range of material from which to piece together the narrative of research active universities in India and the case study institution, set out in detail in Appendix D.

The data consolidation processes from document analysis, observation and interviews were repeated iteratively over an extended period of study, including setting out the details of the case, coding of data, interpretation of single instances, identification of patterns, synthesis of perspective and conclusions that could be generalised to the research problem (Cresswell, 1994; Babbie & Mouton, 2001).

3.5.1 Coding processes

Open coding was used to identify the categories that arose from the responses of the key informants with attention to categories for conditions, for strategies and for consequences. The initial coding is set out extensively in chapter 4 through 8, then summarised in chapter 9. Inductive reasoning was used to think about and define categories and sub-categories. Open coding was conducted throughout the research process, in order to direct further data collection. Axial coding was used to consider connections among the various categories and sub-categories of data and mainstream views and alternative views were identified. This enabled the approach to theory formulation as recommended by Babbie and Mouton (2001, p.498-501), setting out the (a) causal conditions – (b) phenomenon – (c) context – (d) intervening conditions – (e) action/interaction strategies – (f)

consequences. This model was applied to ground the concepts that arose in the study. Memos were used at various stage of the data collection process to clarify the processes unfolding and the meaning of the data. In addition, a few journal articles and book chapters were published as discussed in the chapters below, creating the opportunity for conceptualisation of perspectives, codes and themes over the duration of the investigation.

Selective coding was employed to identify the core category and to systematically relate the other categories to this core category, supported by explanation of the relationships. This process of selective coding was the discovery process that enabled preparation of the storyline for the object of study and provided the basis for detailed analysis and establishment of patterns. Finally, a theoretical framework was developed grounded against the data (Charmaz, 2000, p.510).

3.5.2 Theory formulation approach

In designing the theoretical framework, inductive and counter-inductive methods were employed. Looking at a subject, examining something we are using all the time – '…we cannot discover it from the inside. We need an external standard of criticism, we need a set of alternative assumptions … Counter-induction is, therefore, always reasonable and it has always a chance of success' (Feyerabend, 1993, pp.20-23). Both inductive and counter-inductive reasoning can be used, inductive to present an *x* view – based on the observations of the researcher and the dominant view from the analysis of the stories told by key informants and counter-inductive to present a *y* view – being an alternative perspective based on a minority view as expressed by the key informants, or a view that is the counterpoint to the view expressed by the majority of participants.

During the phase of theory design, it was necessary to review literature on the central theme of entanglement, which led the author to borrow the digital editions of a book from the Open Library, where it is possible to check out the book or reserve the book if it is checked out of the library; to download Adobe Digital Editions 3.0 for either Windows or Macintosh; then download the ebook either in pdf or in epub version and load it in Adobe Digital Editions for ease of reading. This is how the author obtained access to a little known book, de Santillana's essay on the origins of scientific thought.

In consideration of the core category for theory building, specific literature was sought and theory testing was conducted as ways of enriching the theory formulation process, which is detailed in Chapter 9.

3.5.3 Issues of validity and reliability

As regards internal and external validity of the findings, these are difficult to establish in qualitative research (Babbie & Mouton, 2001, pp.122-125) and even more difficult to establish in grounded theory research, where the aim is to advance new theoretical insights. In this study, internal validity, or the extent to which the data and analysis resembles 'reality' (Cresswell, 1994, p.158), was addressed through examining the study themes from many angles; while external validity, or the extent to which the study findings may be generalised (Cresswell, 1994, p.158) was addressed through explaining whether the theory has limited application to South African universities or broader application to universities. Reliability (Babbie & Mouton, 2001, p.125), or the likelihood that a similar approach would yield similar results in other research active universities, was important for this study, because the purpose of the study was to consider trends. Reliability can be ascertained to the extent that data for each small case study was gathered from different parts of the large institution, from academics and administrators in departments, schools, faculties, committees, the library, Wits Commercial Enterprise and other parts of the institution. Thus, congruencies and dissimilarities could be highlighted and analysed.

3.6 Rationale for the study of university research positioning and major contribution of the research

The current positioning of universities in emerging knowledge economies may be more appropriate to industrial or services-based economies than to a knowledge-based economy. The mission of increasing research activeness has appeared elusive, as universities have struggled to make the transition from advanced teaching institutions with a research base to institutions engaged in entrepreneurial research, social research and innovation, in a competitive global higher education landscape. Uncovering the nature of and factors affecting change in universities with respect to research activeness and research intensiveness would be enlightening for many institutions who seek to transition to research practice or who seek to significantly increase research practice.

The major contribution of this research is to understand what challenges and blockages exist to building socio-scientific innovation and research intensiveness and to construct a theory of universities in formative knowledge economies, as a basis for understanding some of the conditions necessary for such research intensiveness. The theory presented in chapter 10 highlights important strategic choices and approaches that universities in emerging knowledge economies may adopt in building their potential for successful advancement of the research profile and practice. The study will be of interest (a) to university leaders in South Africa and in emerging economies attempting to understand the increasing complexity of universities and manage the increasing demands for research activeness and research intensiveness; (b) to higher education policy-makers who wish to chart a course that enables university systems to mature as 21st century systems on the African continent and in emerging economies.

3.7 Chapter outline

Chapter 1 discusses the context for university in emerging knowledge economies. It presents perspectives on the changing context of universities, with particular

attention to South Africa, BRICS countries and India, and with respect to the selected case study institution, Wits University.

Chapter 2 is the literature review and discourse analysis relating to the university in the knowledge economy context, with references to theories of entrepreneurial science, the triple helix of university-industry-government linkages, technology transfer and commercialisation. It views contemporary theory as limited in explanatory power.

Chapter 3, the methodology chapter, discusses the philosophical approach and theoretical perspective, the grounded theory research design and the case study method. It provides an overview of the data collection and analysis process, which is further detailed in subsequent chapters.

Chapter 4 provides a perspective from India, drawing lessons from Indian universities, higher education institutes and higher education governance institutions. The chapter generates themes reflecting on the Indian experience of university transition in an emerging knowledge economy and codes for theory building.

Chapter 5 presents the overview of research at a large research-based university in South Africa. It provides the foundation for understanding the institution, its research practices and strategy over the breadth of the organisation. This provides the opportunity to situate the three specific case studies in the broader institutional context.

Chapter 6 documents the first case study on the evolution of research at the Joburg Centre for Software Engineering (JCSE). It reviews the nature and complexity of research partnerships in the context of Gauteng as a globally competitive city region. Chapter 7 documents the second case study on the

values and value of the Agincourt Health and Population Unit, located in rural South Africa approximately 450km away from the university's main campuses. Chapter 8 documents the third case study on the co-existence of intellectual property (IP) management approaches and open access to knowledge in scholarly communications. Each of these chapters presents detailed data and brief analytical commentary.

Chapter 9 is the detailed analytical chapter, setting out the categories and themes and the formulation of the grounded theory. It documents the common categories, concepts and patterns; the interconnections between common categories, concepts and patterns; and creates the storyline for the grounded theory. It considers possible causalities, but does not interrogate them at length. It elucidates the theory of university positioning for research activeness/intensiveness through research entanglement. Chapter 10, the concluding chapter, presents a detailed statement of the theory, and sets out the context within which the theory is applicable.

3.8 Limitations and delimitations of the study

The delimitations for this study were as follows: The study focused, in particular, on (i) a review of a proxy group of universities in India, (ii) overview of the South African case study institution, (iii) a small selection of segments of the case study institution for in-depth study, (iv) a selection of institutional processes for in-depth study. The study did not explore the university in its entirety. The study did not explore other research-based universities in South Africa or other knowledge-based institutions. Reference was made to the context within which the university functions however the context itself was not studied.

With respect to limitations: As regards the India perspective, only eight institutions were reviewed, limited to institutions based in Delhi. These institutions were viewed as a proxy group for large, research-based universities

in India. While the study intended to offer a perspective on research-based universities, it reviewed only a single South African university, namely Wits University, as a case study. The rationale for this approach was that the researcher was able to build an in-depth view of a single institution, which is broadly similar to other such institutions, rather than comparing like institutions with each other, or collecting case studies from a number of institutions. The benefit of the approach was that the data collection and analysis could focus on an institution and derive an institutional perspective, rather than review a set of exemplar projects or undertakings, which were not collectively embedded in an institutional setting. It is noted that the researcher is required to generate the "core category" and the "beginning theory", with "original completeness", rather than present extensive theorisation (Glaser, 2012).

As the researcher is an employee of the institution being studied, possible researcher bias was managed by presenting the findings and analysis to a selected group from among the key informants and inviting comment.

3.9 Summation of methodology

In the data collection process, around 75 documents and 11 websites were reviewed to build the India perspective on higher education presented in Chapter 4 and the South Africa case study institutional overview and in-depth case studies presented in Chapters 5 to 8 (see Appendix D), notes were made on data and events from seven specific observation incidents and nine participant observation incidents (see Appendix E) and 34 interview conversations were held with key informants in India and South Africa (see Appendix F). Immersion in the subject matter was significant, including seven weeks spent teaching and conducting thesis research in India; and immersion in many aspects of the South African case study research. This immersion, iterative data collection and coding, and final theory building was in line with the grounded theory methodological approach.

Chapter 4 Case Study A: Exploratory study on changing paradigms in higher education: The university research sub-system in India

Universities in emerging knowledge economies are operating in a chaotic global economy affected by recessionary conditions, where access to the human resources and funding to practice research is highly competitive (Marginson, 2010; Mashelkar, 2008). In this state of global competition for knowledge resources, many universities and higher education institutions look to measures that have evolved and been adopted in the United States of America and Western Europe to address these challenges, such as concepts of the triple helix of university-industry-government relations (Ery Supriyadi, 2012). While exploring these themes will be enlightening to university leaders and policy-makers, it is pragmatic to explore trends that arise in universities in emerging economies like India and South Africa, countries shifting from efficiency-driven to knowledge-driven or innovation-driven economies (Porter, 1990; Acs, Desai & Hessels, 2008) in the first decade of the 21st century.

4.1 Indian higher education research activeness: Seven themes of complexity

The subject of this chapter is the exploration and formulation of themes from Indian higher education change that may present ideas relevant to the positioning of universities in emerging knowledge economies. The chapter commences with a contextual overview of and relevant data on selected Indian higher education institutions and research production. The chapter then presents the data pertaining to eight specific themes in university reform with respect to research. In a review of four central universities, one institute of national importance and one autonomous business school conducted for this thesis, seven relevant themes were observed: (i) numbers, quality and research games; (ii) advancing university research under adverse conditions; (iii) inter-disciplinary research and teaching; (iv) ICT as an enabler of learning and research; (v)

research resources made available by inter-university centres; (vi) applied research on social agency and social innovation. The seven themes encountered during the course of the study relate to the complexity of research development in Indian higher education. Based on the qualitative data, the chapter briefly explores an understanding of the overarching ideas arising from analysis of these themes, pertinent to the formulation of a theory of universities in emerging knowledge economies, which will be presented in Chapter 9.

Fourteen interviews were conducted with 15 respondents including university leaders and professors over a period of seven weeks in Delhi from December 2007 to January 2008, using semi-structured interviews. These key informants were selected on the basis of (i) introduction to particular respondents by one of the key informants (ii) identification of respondents based on a website review of central universities in Delhi and (iii) a snowballing method, with particular interviewees proposing additional persons to be interviewed.

4.2 Overview of higher education study institutions in India

In 2010, India was recorded to have 504 universities and tertiary institutions and more than 26,000 colleges, with a gross enrolment ratio in higher education of 12% (Gupta & Gupta, 2012). This thesis is interested in the 40 central universities, the 33 institutions of national importance and the autonomous business schools, because these institutions are engaged in research practice. The chapter reviews perspectives from six universities and institutes, listed below. Insight was also obtained from the National Institute of Science, Technology and Development Studies (NISTADS), a unit of the Council for Scientific and Industrial Research India. Each interview provided the basis for a conversation in the next interview, including confirmatory statements and explanatory statements.

Jamia Millia Islamia (JMI), located in Delhi, was established in 1920 and became a central university in 1988. JMI has nine faculties and more than 20 research

centres, including the Centre for Early Childhood Development and Research, Centre for Interdisciplinary Research in Basic Sciences, Centre for Nanoscience and Nanotechnology, Centre for North East Studies and Policy Research, Centre for Spanish and Latin American Studies, Centre for Theoretical Physics, Centre for West Asian Studies, and the Nelson Mandela Centre for Peace and Conflict Resolution (JMI, 2011, pp.5-7) (*coded as research-oriented institutions*). The Centre for Theoretical Physics increased their publication count from four journal articles in the year of establishment 2006 to 34 journal articles in 2012 (JMI, n.d.). Almost 20,000 students were enrolled in 2010 (JMI, 2011, p.9) and the university had 656 full-time academics and 318 visiting, guest and part-time faculty (JMI, 2011, p.604).

Jawaharlal Nehru University (JNU), also located in Delhi, is a central university established in 1966 as a dedicated post-graduate institution for teaching and research. In 2008, JNU had 10 schools and 35 research centres, including the Centre for Sanskrit Studies, Centre for Molecular Medicine, Centre for Computational Biology and Bioinformatics, Centre for Chinese and East Asian Studies, and Centre for Studies in Science Policy (JNU, 2008, pp.2-6), a few recognised as centres of excellence by the University Grants Commission (*coded as research oriented institutions*). JNU engages in collaborative partnerships with 12 Indian R&D institutions including the Inter-University Accelerator Centre and the Inter-University Centre for Astronomy and Astrophysics (JNU, 2008, p.7). In 2007-08, 5,454 students were registered at JNU, of which 3,241 students were enrolled for research degrees (JNU, 2008, p.7). In 2008, JNU employed 469 professorial level staff (JNU, 2008, p.8).

Mizoram University was established as a central university in 2000. Located in rural north eastern India bordering Bangladesh and Burma, in a rural economy dominated by agriculture, forestry and services, the university's unique areas of study include the work of the Department of Horticulture, Aromatic and

Medicinal Plants located in the School of Earth Sciences and Natural Resource Management, appropriate for this rural location (Mizoram University, 2008) (*coded as research oriented institutions*). The university had a relatively small post-graduate cohort of students of 173 PhD enrolments and 651 other postgraduate enrolments in 2007-08 (Mizoram University, 2008, pp.198-199).

Visva-Bharati University, inaugurated in 1921 was declared a central university in 1951. A small university with approximately 6500 students, it is comprised of 11 institutes each incorporating a number of departments and 12 research centres. It hosts research centres for agro-economic research, biotechnology, environmental studies, women's studies and the Institute of Tagore Studies and Research; and was the alma mater of Nobel Laureates Rabindranath Tagore and Amartya Sen (Visva-Bharati, n.d.) (*coded as research oriented institutions*).

The Indian Institute of Technology (IIT) Delhi was declared an institution of national importance in 1963 and awarded the status of a university. It hosts 10 research centres (including atmospheric sciences, energy studies, instrument design and polymer science) and one centre of excellence (cyber systems and information assurance) (IIT Delhi, n.d.). The institute has a strong research profile, in research produced, published and in PhD programmes. The Industry R&D Unit provides administrative support to the institutes departments and centres with respect to institute-industry interaction; patents, know-how and technology transfer; as well as provision of research assistance grants to new members of faculty (IIT Delhi, n.d.). In 2013, the institute hosts 38 research chairs, mainly industry funded, including the TRIPP Chair for transportation research and injury prevention, the programme studied for this thesis (*coded as research oriented institutions*).

Management Development Institute (MDI) Gurgaon is an autonomous business school established in 1973 in one of Delhi's three emerging satellite cities at

Gurgaon. Applied research is fostered through six research centres including the Centre for Corporate Governance and Centre for Entrepreneurship and the business school ensures that "knowledge gained through research is applied by the faculty in their consulting assignments…(and in) books, research articles in reputed international and national journals…" (MDI, 2008, p.16) (*coded as research oriented institutions*).

The All India Council for Technical Education (AICTE) was created by an Act of Parliament to promote planning, co-ordination and quality improvements in technical education, and to regulate norms and standards in the technical education system, which includes universities and other higher education institutions (All India Council for Technical Education, n.d.; Government of India [GoI], 1987). The AICTE includes in its brief the need to respond to recommendations from other bodies on issues pertinent to its legislative mandate, such as the recommendations of the National Knowledge Commission. The University Grants Commission was established by an Act of Parliament in 1956 to focus on co-ordination, determination and maintenance of standards for approved universities including central universities, state universities, deemed universities and private universities (GoI, 1956; UGC, n.d.).

Data collection from these eight institutions provided a reasonable degree of insight into the challenges for university and higher education research in India, though the limitation of the short duration of immersion in this higher education environment means that only limited inferences could be drawn for theory building at a high level of coding of themes. Nevertheless, the exploratory nature of the data collection and analytical coding provided a foundation for more in-depth research in South Africa, as it elicited data categories for further investigation.

4.3 Higher education – a numbers, quality and research game

The discourse in higher education in India considers higher education as key to economic development and social growth, to building the Indian knowledge economy, requiring a significant increase in the numbers of young people enrolling and graduating from technical education institutions (observation incident 3: AICTE conference 17-18 December 2007). In 2007, 1,200 engineering colleges were producing 300,000 graduates per year, while 7 IITs produced 2,300 graduates per year (AICTE, 2007). Despite these numbers, only 12% of the relevant age cohort is entering higher education (Gupta & Gupta, 2012). Furthermore, India is unable to meet the knowledge demands of its indigenous companies, multinationals and society at large (AICTE, 2007). While the Indian institutes are world renowned for high performance, they are limited in number and demand for high quality graduates exceeds supply (*coded as research resources; coded as university games*). The demand is for access to scientific and technical education (key informant UGC-S, 2007):

> From the dawn of independence, the nation as a whole demonstrated a great faith and commitment to the use of science and technology as an instrumentality for national development, which resulted in great success stories in certain mission areas such as the green revolution, space science and IT. But despite this confidence and commitment to science and technology as a tool for development, there have been problems. If technical education is going to be a carrier of national development, then the question is how accessible is technical education going to be.

Different viewpoints (key informants MDI-PPM, 2008; key informant MDI-POB, 2008) argue the importance of the contribution of the social sciences and humanities to knowledge for societal development, stating that social and financial engineering will become more relevant, and that music, medical and creativity engineering will become more important in universities (*coded as research value*).

Technical education is stratified horizontally and vertically along many lines of social stratification including gender. It was argued that there have been only

half-hearted attempts to bring about gender equality (key informant JMI-SM, 2007; key informant JNU-SM, 2007), and that while the representation of women in some of the central universities is reasonably high, there is hidden discrimination. It was further argued that for enough women to be equipped to take up professorial posts, a greater availability of women is needed in the university (*coded as research resources*).

The "access with quality" debate in research (*coded as research values*) relates, amongst other things, to the tendency to reproduce research questions and methodologies from articles published in international journals and apply them in the Indian context, as compared to undertaking research that is both novel and relevant in the Indian context (key informants MDI-PM; MDI-POB). At the AICTE conference, the view was expressed (AICTE conference presentation, 2007):

> if we want to be leaders in the knowledge economy, we have to spend more time on the best institutions, making them better, encouraging inter-disciplinarity and modularity, however we have been concentrating on improving those at the lower level.

In a related interview discussion, the broadly applicable point was made that (JMI-SM, 2007) (*coded as research values*):

> It will require a great deal of imaginative thinking to reject the out-dated values that have dominated higher education, however, a globalised society can be seen as a means of moving up in the world.

4.4 Advancing university research

Interviews with senior managers and scientists at a few universities permitted insight into the conditions under which universities in India are building research programmes in the early 21st century.

4.4.1 Building university research under conditions of adversity

Historically universities in India did not have a research mission, instead government research institutes were established as distinct from universities and the best researchers were located at research institutes (key informant JMI-SM, 2007; key informant JMI-PBS, 2008). These key informants explained that during the 1950s and 1960s, the government research budget was allocated to research institutes rather than to universities, thus the performance of the research institutes and laboratories could not benefit from an association with university academics and postgraduate students (*coded as research resources*). Furthermore, during the 1970s and 1980s, Indian professors at central universities sought funding from various agencies to establish the research mission, operating under adverse conditions of limited resources and research infrastructure (*coded as research actors; coded as research values*).

From the mid-1990s, central universities introduced research and scholarly publishing as a requirement for promotion, focusing attention on publication in peer-reviewed journals, impact factors and citation indexes (key informant JMI-PBS, 2008) and the requirement for research publication as a measure of performance has increased across universities and other higher education institutions in the decade following release of the NKC (2006) report (key informant MDI-PM, 2014) (*coded as research values*). However, by 2013, incentive structures for research publication were becoming more prevalent, with some institutions offering individual financial incentives for publication in academic journals with high impact factors (key informant MDI-PM, 2014) (*coded as research resources*).

Research has advanced slowly but significantly in the biological sciences, and research in protein folding and stabilisation, exploration of bio-nanotechnology in human genetics, medicinal and polymer chemistry and other fields contributes to building the knowledge base of India (key informant JMI-PBS, 2008) (*coded as*

research value). Scientists from the engineering and technology faculty were invited to serve on the advisory panels for pharmaceutical companies. Scientists in physics, chemistry and life sciences were working to develop patents (*coded as research value*). However, JMI was not yet engaged in commercialisation of novel technologies (key informant JMI-PBS, 2008), though other forms of technology transfer were noted. This includes collaborative research with institutes such as the National Physical Laboratory (NPL), the International Centre for Genetic Engineering and Biotechnology (ICGEB), the National Institute of Immunology, and the All India Institute of Medical Sciences (AIIMS). As stated by this respondent (key informant JMI-PBS, 2008) "…so research finds its way into the life of society…technology transfer happens" (*coded as research value*). Another concern expressed (key informant, JMI-PBS, 2008) was that while much applied research was being pursued, university research was not yet moving towards innovation outcomes, which were expected to emerge within a further 10 years (*coded as research value*).

In the humanities (key informant JNU-PAA), establishing research in arts, culture and aesthetics proved challenging, taking more than 30 years to get off the ground due to prioritisation of focus on art history, art theory and art criticism as compared to art practice. Funding was experienced as a highly complex endeavour, with funders finding the area of research alternatively attractive or risky (*coded as research resources*).

4.4.2 Policy change for fostering university research 2006-2008

The legacy of weak innovation system formation in India was apparent in the low levels of resource inputs in terms of GERD estimated at 0.76% in 2007, as well as the limited registration of patents and systemic weaknesses in commercializing research (Dutta, 2012, p.344; OECD, 2011). While India's contribution to scientific publications was exceeded by only nine countries (Canada, China, England, France, Germany, Italy, Japan, Spain and the US), its

publication count per thousand inhabitants in 2009 was listed 39 out of 40 countries (OECD, 2011, p.94). The National Knowledge Commission (NKC) report attempted to address some of these weaknesses with respect to university research (NKC, 2006, p.45):

> Universities must become the hub of research once again to capture synergies between teaching and research that enrich each other. This requires not only policy measures but also changes in resource allocation, reward systems and mindsets.

Further recommendations included increasing government investment, while also attracting foreign direct investment (FDI) and knowledge investment (KI). The NKC report (2006, p.44) presented a range of financing options for consideration and recommended that 1.5 per cent of India's GDP should be spent on higher education, tax incentives should be considered to fund research and universities should seek income through licensing their intellectual property (*coded as research resources*). The 2007 NKC report included recommendations on open access publishing (NKC, 2007, p.51), on developing human capital for commercial innovation (NKC, 2007, p.53) and on promoting university-based intellectual property through patenting, licensing and commercialisation (NKC, 2007, pp.59-60) (*coded as research values*). The interviews and reports clarified that the university R&D component of the broader innovation system requires significant strategic development. These requirements for greater productivity in higher education in general and greater research activeness in particular, increase the complexity of participating in higher education for those research actors who have already achieved a measure of research activeness in terms of producing novel discoveries and publishing their work, while introducing a major culture change for those academics who were mainly focused on teaching.

Working in this state of complexity, the NKC recommendations would require a significant response from government and from the higher and technical education sector itself. Central government planned to establish 30 new central

universities, to introduce engineering and management faculties in all central universities, to fund eight new Indian Institutes of Technology, seven new Indian Institutes of Management, and to enhance the capacities of the existing IITs and IIMs. In addition, government planned to fund five Indian Institutes of Social and Economic Research, two Schools of Planning and Architecture, 10 National Institutes of Technology, 20 Indian Institutes of Information Technology and 50 centres for training and research in frontier areas of knowledge (AICTE, 2007) (*coded as research oriented institutions*).

The AICTE conference sought to construct a response to the NKC recommendations from the higher and technical education sector, noting the government responses to increase the size of the sector and to fund research (observation incident 3, 2007). Academic reforms proposed at the conference included measures to encourage students to engage in research and innovation (AICTE, 2007, p.28), faculty development for leading R&D activities (AICTE, 2007, pp.38-40), making research available on the Internet to improve the quality of new theses, incentives for publication in high impact journals and engagement with universities in conducting research at PhD and Masters level, requiring the building of the industry-institute-interface and academic partnerships (AICTE, 2007, pp. 42–44) (*coded as research values*).

4.4.2 Evolution of university-based research strategy in India: 2008-2013

Following government decision-making in 2007-08 to make research obligatory at universities, four major changes occurred (key informant MDI-PM, 2014). Firstly, government mobilised additional resources for education by imposing two kinds of overriding tax on personal income tax, including a 1% tax for higher education. These taxes may not be diverted for any other use (*coded as research resources*). The second step was the regulatory aspect, "the regulatory battle is peaking at the moment" (key informant MDI-PM, 2014) with various stakeholders lobbying governmental bodies to identify who would take

responsibility for which aspects of the proposed changes pertaining to support for university-based research. Government was investigating whether the UGC could shift from providing financial resources to becoming the regulatory and standards body for higher education, thereby linking resource allocation to quality assurance processes and outcomes (key informant MDI-PM, 2014) (*coded as research values*).

A third tactical element reported in this interview was that government started cherry picking institutions of exceptional skills, providing one-time extraordinary grants through the national budget. The first recipient was the Indian Institute of Science (IIS) in Bangalore, given a grant of one billion Indian rupees in 2012, and two further recipients awarded grants in 2013 were Visva-Bharati University and Aligarh Muslim University. The plan is that, every year, government will give mega funding of INR1 or 1.5billion[8] to one university, rather than giving incremental funding on a year-by-year basis (*coded as research resources*). This bulk funding approach is designed to assist planning for the longer-term research programme. The experiment is innovative and seems to be working (key informant MDI-PM, 2014). IIS Bangalore research output has increased and the future impact of this research could enable the institute to attract more research funding as it gains greater visibility. Furthermore, industry is being encouraged to collaborate with academic institutions through provision of tax incentives (*coded as research resources*).

Fourthly, as regards promotion for academics, it became mandatory that no promotion would be confirmed without evidence of published research, evaluated through the Thomson Reuters Web of Science/Web of Knowledge impact factor and the total number of publications. At the level of a particular institute (key informant MDI-PM, 2014), research has become mandatory, providing monetary incentives to academics to publish, and a Thomson Reuters

[8] INR = Indian rupees

factor of more than 1.6 (A) will result in a take home incentive equivalent to four months salary (*coded as research values*), distinct from research funding grants.

This new ecosystem is being created to support research, but the challenge will be the availability of human resources to carry forward the agenda. While there is a visible increase in the number of people registering for PhDs and research degrees, the effects of this particular increase will only be observed in seven to 10 years (key informant MDI-PM, 2014).

The following sections introduce data on important perspectives pertaining to measures required to foster research production and ways of thinking about university research.

4.5 Multi-disciplinary and inter-disciplinary teaching and research

Encountering complexity in promoting multi- and inter-disciplinary research, universities were observed to adopt differing approaches. The vision of JNU was to evolve policies and programmes that will make the university "a valuable addition to the national resources in higher education rather than a mere expansion of facilities" (key informant, JNU-SM). Hence, from inception the approach was inter-disciplinary teaching and research, for example botany and zoology, history and political science. No school operated in a single discipline, but encouraged problem solving by students and academics from different disciplines (*coded as research values*).

Many universities emulated the JNU approach to inter-disciplinarity from the 1980's, though not without encountering complexity related to the relative weakness of scientific research funding and practice in universities as compared to research institutes, to the greater attractiveness of industry for young graduates, and to the absence of a new generation of researchers in the natural sciences, particularly with respect to basic scientific research (key informant JNU-

LS+BI, 2008). Despite pursuing certain forms of inter-disciplinarity, very few faculties made concurrent appointments of academics across faculties (*coded as research values*). Furthermore, universities were reluctant to engage industry in research due to the concern that industry would dictate research direction, though this view was changing as interest in patenting and international patent registration grew (key informant, JNU-LS-BI, 2008).

Jamia Millia Islamia (JMI), competing with two well-established institutions, JNU and the University of Delhi, sought to carve a niche for itself by launching research centres and new knowledge fields in which the university would be able to flag the centres as pioneers, including inter-disciplinary studies and third world studies addressing population, poverty and global affairs (JMI-SM, 2007; JMI-PBS, 2008). JMI-SM commented that this greater interest in global affairs was apparent in India, Pakistan and other countries of the South Asia region[9] (*coded as research value*). The particular challenge of building multi-disciplinary research in the natural sciences was described as follows (key informant JMI-PBS, 2008):

> My knowledge foundations are (located in) physical chemistry with an introduction to biochemistry, thus I can study the physical chemistry of a biological problem. All the time, I feel I need more biology, physics and maths (knowledge). The aim (of the research programme) is to select a biological problem and work (across) disciplines to try to understand the problem…to remove the handicap, remove barriers and open up new opportunities for research…(to address) demand created in the society…pressure from funding agencies (to show) the utilisation of the research outcomes, (we) have to justify, show benefit…pressure to do applied research.

One of the strategic approaches used to build capacity for multi-disciplinary research was the establishment of PhD level programmes to address the deficiencies of postgraduate students to engage in multi-disciplinary research. The design of the PhD programme sought to remedy deficiencies, so that, students could be formed into research teams working with selected faculty

[9] South Asia consists of nine countries namely Afghanistan, Bangladesh, Bhutan, India, Iran, Maldives, Nepal, Pakistan, Sri Lanka.

members (key informant JMI-PBS, 2008) (*coded as research resources*) to tackle interesting research problems for India in bio-nanotechnology, protein DNA and drug interactions, bioinformatics, molecular immunology, structural biology and systems biology, with the emphasis on constructing entirely new fields of knowledge. It was argued that research universities should focus on new fields of knowledge (key informant JMI-PBS, 2008), noting its attendant challenges (*coded as research value*).

4.6 ICT "the biggest enabler" of learning and research

JMI-SM commented that "ICT has dramatically changed university life" and that students were more engaged in learning and appeared to be more productive, as ICT access broadened the learning process beyond the classroom and gave students a sense of self-empowerment unique for students from a relatively poor background. JNU-LS+BI reported that availability of electronic journals had changed teaching and research because of access to contemporary knowledge, and had also changed research behaviour in that academics were regularly seeking new ideas from e-journals and incorporating these into teaching and research. Attention was also needed to ailing physical infrastructure and human resources needed to make the ICT infrastructure pay dividends (JNU-SM) (*coded as research resources*).

JNU was fully networked with Internet access for all students, as well as access to all local online journals and selected international journals. The Management Development Institute (MDI) (Gurgaon) provided high-speed broadband Internet access and electronic library access in all its residences 24/7, in addition to Internet access in its computer facility and in the library. The JNU School of Arts and Aesthetics (JNU-PAA, 2008) was entirely dependent on ICT for access to film screenings, clips, slideshows and other web-based resources (*coded as research resources*).

4.7 Research resources made available by Inter-University Centres

In 2008, India had six Inter-University Centres (IUCs), providing high-cost academic infrastructure in the fields of nuclear science, astronomy and astrophysics, physics and electronics, and e-learning, to universities, for academics to conduct research, short sabbaticals and to popularise science amongst young students. One of the most important IUCs was the Consortium for Educational Communication (CEC), which made videos by eminent scholars, resulting in courseware for 11 subjects across the natural and social sciences. Fifteen thousand programmes were made available in the national video library by 2008 (UGC-S, 2008) (*coded as research resources*).

4.8 Social agency and innovating for society

Socialisation of knowledge was regarded as an important contribution from higher education (MDI-PPM, 2008). For example, government officials on the public policy programme at MDI Gurgaon designed an action plan for schooling of the children of villagers migrating to the city, who were not registered at local schools. The programme participants held interviews with the migrants and presented the action plan to the MDI faculty, following which they would make a presentation to the Gurgaon district administration. While social innovation was not common in Indian universities at the time, some universities have played a prominent role in social development, for example agricultural colleges, public policy schools, and universities located in "tribal" areas. These universities will have a stronger component of designing work and curriculum for the benefit of local communities (MDI-PPM, 2008) (*coded as research value*).

Mizoram University provided another insight into universities and social agency. Its Department of Forestry in the School of Earth Sciences and Natural Resources Management, was co-operating with the government and communities of Mizoram to develop the area's potential as a forestry and hydro-electronics

centre, though extension activities were relatively modest (Mizoram University, n.d.):

> The department aims to produce efficient and skilled manpower for sustainable management and utilization of forest and biodiversity resources of the area. It visualizes not only to impart quality education and skill to the students but also to carry out quality and need based research, the outcome of which can be extended to the people of the region for making forestry sector as an important income generating source on sustainable basis.

Due to a strong NGO movement active since the 1930's, there was a tendency for students to forge close links between what they do at university and what the society needs, but this did not always take the form of formal programmes. The experience there is "not what would be observed in a large metro area" (MU-SM, 2008) (*coded as research values*).

The Transportation Research for Injury Prevention Programme (TRIPP) at the IIT Delhi, founded on a combination of entrepreneurial research and civic mindedness (IIT-TRIPP, 2008), was established to focus on transportation sector issues including pollution, traffic congestion and road safety, based on multi-disciplinary research (key informant IIT-TRIPP, 2008):

> We at TRIPP are the first group where the different backgrounds of faculty from departments including civil and mechanical engineering, computer science, applied mathematics and social studies come together and the professors work … to understand the current situation of transportation in all Indian cities...

These research needs were expressed by a range of stakeholders including NGOs working with lower income groups living in housing clusters or in slums. This search for social innovation introduces a new dimension to the purpose of research in Indian universities and institutes (*coded as research values*).

4.9 Insights for theory building and prods for further data collection

From the above selection of themes from Indian higher education, a few inferences and insights emerge that guide the research in its search for theory and for future lines of enquiry and data collection.

The commonly conveyed objectives that emerged from the interviews included contributing to indigenous knowledge generation and making research accessible to millions of young people, a highly complex undertaking, as advised by the key informants and by published research such as Gupta and Gupta (2012). The Indian transition to research activeness and intensiveness is being pursued through a mixture of strategies, some of which have similarities with those encountered in the literature from more advanced knowledge economies, while some strategies such as the rapid establishment of large numbers of universities and other higher education institutions, the introduction of extraordinary funding for research and personal research incentives are novel. In the process of reviewing the data, three main categories of data can be induced, namely (i) responses to research complexity (*coded as research actors, research oriented institutions*) (ii) fostering research despite adversity (*coded as research values and value*) and (iii) the challenges of attracting research resources (*coded as research resources*).

4.9.1 Complexity of research production at universities in India

Analysis of the data in this exploratory review of India's central universities, technology and management institutes, and higher education governance bodies reveal that these institutions have made explicit their objectives to increase research activeness (a continuous cycle of research production and publication) and for some central universities to build research intensiveness (establishing new fields of enquiry and research in new multi-disciplinary fields, patenting, and publication in high impact international journals).

The data further reveals that high levels of complexity are present in the research-based actions and interactions of scientists with each other, and scientists with university management. Such complexity includes the requirement to increase research performance under conditions where there is high demand for teaching and postgraduate supervision; the challenges of

building multi-disciplinary and inter-disciplinary research under human and knowledge capacity constraints; the limited attractiveness of the university sector as a career; and the major change in academic values required in terms of the policy recommendations of the NKC related to research performance and commercialisation of research. While relationships do exist between universities and industry, the university-industry interface appears to be a confusing landscape with lack of clarity on the best form of future relationships that will permit innovation from research while maintaining the academic freedom of universities.

Many measures to encourage research activeness are at an early stage of adoption, such as access to e-journals and electronic educational resources, building postgraduate programmes as foundations for multi-disciplinary research, and measures to foster a significant increase in the number of publications in top quartile academic journals and other journals per thousand inhabitants. Yet other measures have not gone beyond the single instance, for example the establishment of the research university as a post-graduate only institution, enabling a dedicated focus on research productivity. Furthermore, the inference can be drawn that complex challenges such as patenting of novel discoveries, technology transfer, commercialisation of research and socialisation of knowledge produced in universities will require attention to the formulation and adoption of specific strategies at institutional and system levels, in addition to the pioneering behaviour of scientists.

From a knowledge economy perspective, access to postgraduate study is an important objective, since it is only with large numbers of young people participating in university-based research and in the broader national system of innovation, that emerging economies can meet their scientific knowledge needs for economic and societal development.

This discussion of the presence and particular elements of complexity in pursuing university research activeness guides the thesis research to the next stage, as understanding this particular form of complexity requires more in-depth study with respect to the behaviour of scientists and university managers, as well as the strategies and values that provide the landscape for university research.

4.9.2 Researchers and scientists become highly functioning beings in circumstances of adversity

The most influential data from this review of Indian higher education was the initiatives taken by university scientists to pursue their own research programmes, to attract research funding during a period when government was not investing in university-based research, to create research centres dedicated to a particular social or scientific thematic field. This phenomenon of pushing through adversity for those scientists who chose to build their research brand and make university-based research a reality raises interest in understanding how scientists pursued their objectives to a point where the objectives set were achieved, either in whole or in part. For example, over several decades, the endeavour of scientists to attract local and international research funding led to real research production in universities, which indirectly influenced the findings and recommendations of the NKC encouraging government financing of university research, and the decision by government to introduce extraordinary funding for research at several billion Indian rupees. The competition for access to research resources illustrates a high level of interest in research and innovation across disciplinary boundaries.

The insights for theory building and further data collection set out in this section point to the need to explore and discover the dimensions pertaining to why universities provide some exemplar cases for increasing research activeness and breaking the boundaries of existing knowledge. This line of enquiry was pursued

in the in-depth case studies conducted in South Africa with the aim to better understand the nature of complexity and adversity in the pursuance of university research activeness and the underlying reasons for gaining ground against such complexity and adversity.

Chapter 5 Case study university: Research sub-system overview: Transitioning from research activeness to research intensiveness

> *Sustained and strategic interaction with business, government, non-government organisations (NGOs) and communities will enable the institutes to enhance the value and relevance of research, and deepen public understanding of the compelling issues of our time* (Wits, 2013a).

This chapter establishes the institutional environment of the case study, providing research statistics at a glance per faculty[10]. A selection of Wits research thrusts (multi-disciplinary platforms to promote intra-institutional research collaboration) and entities is briefly discussed to illustrate various forms of research complexity across faculties. This selection was based on a continuous review of university annual research reports from 2009 to 2012, though most cases noted here are from the 2009 report, being the early stage of the study. This institutional review provides an insight into the breadth and characteristics of research at the case study institution, as the context for the specific case studies selected for in-depth investigation.

The institutional review illustrates that the specific entities and activities chosen for profiling are located within a particular research milieu of transitioning towards increasing research activeness and fostering research intensiveness. This transition is related to objectives and motives addressed in the literature on universities in knowledge economies, reflecting strong interests in knowledge contributions to economic, environmental and social development, further reflecting that marketization of knowledge can be profit-oriented but also development-oriented. It is not claimed that the in-depth studies are narrowly or

[10] There were differences in the staff complement data reported by the Human Resources division and the Wits Business Intelligence HEMIS data, though the differences are not material to the study.

directly representative of other research entities and research practices at the institution, but rather that the case studies reveal features of the real world of knowledge production and transitions through research activeness to research intensiveness.

From an epistemological stance, the knowledge is constructed through the review of texts and socially constructed through the interview-based utterances and narratives of scientists and academics. This is not emphatic identification or phenomenological reflexivity as applied in interpretivist studies (Schwandt, 2003, p. 192). This approach is akin to constructionism (for data sourced from documents) and to social constructionism (for data obtained from respondents), applying analytical thinking to the data to formulate codes that enable and guide the formulation of grounded theory. At the most basic level, the epistemological stance taken is that the data that creates definition of the subject being studied, the utterances of the respondents and the narrative that unfolds from the documentary review and the many respondents, presents an opportunity to form an "understanding of social practices" (Schwandt, 2003, p. 197) with respect to research activeness and research intensiveness.

The context for this study is the shift towards knowledge economies occurring in several emerging economies including in India, South Africa and other BRICS countries. The research interest is to understand the efforts to foster university research as part of sustaining a national innovation system comprised of universities, firm level R&D, science-based institutes producing innovation and national scientific facilities supporting R&D, how universities seek to transform their research capacities and outputs. The case study chapters (chapters 4 to 8) seek to understand the underlying patterns in building university research activeness (i) commencing with the short study in Indian research-active universities and (ii) continuing with more in-depth studies at a single South African university. The chapter is written as alternate data presentation and

conceptualisation, as this is appropriate in terms of the structure of the thesis, where there is a theory formulation chapter but no distinct analytical chapter.

Furthermore, this approach of contiguous data presentation and conceptualisation is applicable in grounded theory as according to Glaser (2002, pp.4-15), conceptualisation of emergent patterns as denoted by categories and their properties is necessary for the formulation of theory. This approach also fits well with the epistemological stance of constructionism and social constructionism as advanced by Schwandt (2003).

5.1 Influences on the design of the study of universities in the knowledge economy

The formal grounded theory exploration for this study commenced with observation at the Wits strategic retreat in November 2007 followed by the seven-week exploratory study at selected universities and institutions in India in 2007-08. At this stage, it had not yet been determined what particular data was being sought for the South African case study hence the observation of the extended strategic leadership conversation at the retreat was open ended. The researcher wished to gain an understanding of universities in the knowledge economy from a developing country perspective and was not interested in seeing how well particular theories of universities in the knowledge economy fit the Indian or South African university. Early observation in the two countries led the researcher to the realisation that it was not necessary to advance the university based research endeavour simply by reproducing ideas from elsewhere, for example promoting theories of entrepreneurial science or triple helix engagement which had evoked interest in South Africa. Instead, the researcher identified the need and the capability to discover indigenously derived knowledge and extemporise theories of universities in the 21st century, of which one particular theory is elucidated in the final chapters of the thesis.

5.2 A perspective on the single case study institution: Wits University

Wits University was founded in 1922 as a mining college, becoming one of the leading research active universities in South Africa and on the African continent. In 2013, amongst South Africa's 23 public universities, Wits featured fifth for the number of Masters graduates (569), second for the number of doctoral graduates (221), fifth for the number of research publications (1300), fifth for the weighted total research output per academic staff member (2,32) and fourth by research income as a percentage of the block funding grant from national government (22.9%) according to the SA HE Open Data project (CHET, no date).

By 2013, Wits had become a recognised global university with a knowledge community of approximately 2,500 academics, 2,200 technical and administrative staff and 30,800 students (Wits, 2013b) with local (city level), national, continental and global research linkages. By 2014, Wits had produced 4 Nobel laureates, hosted 20 South African Research Chairs (NRF/DST funded initiative), five Centres of Excellence, multiple research thrusts, institutes, units and groups, and approximately 250 rated scientists, of which 16 are A-rated (Wits, n.d.a).

Wits is situated in an urban environment where its most geographically immediate governmental institutions, the City of Joburg and the Gauteng Provincial Government have expressed their strategic intent to become, respectively, a world class African city and a globally competitive city-region (GPG, 2006). These initiatives explicitly recognise the importance of universities, firstly as generators of knowledge inputs for socio-economic development; secondly as providers of graduates, in particular in scarce skills domains of engineering, management and entrepreneurship; and thirdly as creators of new knowledge in the form of research and innovation outputs (GPG, 2006). Among South Africa's universities, Wits is perhaps the most culturally industrial, having built strong research foundations in fields such as mining engineering, geology, chemical engineering and public health. Culturally industrial is a descriptor that

can also be applied to Wits' research on the sociology of Johannesburg, including work on trade unions, which fed into the revival of the trade union movement in the 1970s; and writing on urban historiography analysing workers and community movements, development of the city and urban planning documented in writings on Wits and in annual research reports (Callinicos, 2012, Wits, 2006 through Wits, 2012).

Universities are constantly evolving, as single institutions and as part of a broader knowledge system. New directions for universities in emerging economies include the identification and protection of intellectual property (IP) in a variety of forms, which include patents, trademarks, plant breeder's rights, as well as copyright and open access licensing for scholarly publications. At Wits, technology transfer and commercialisation of IP aims to create opportunities for commercial use and profitability, or for social impact that generates limited financial return yet produces value from publicly funded research (review of Wits Commercial Enterprise website, 2011-2012). How should we understand the trends and tropes related to repositioning large, research active universities in the emerging knowledge economy?

Ninety years after its formation, the challenges for Wits University can be looked at from three perspectives (1) innovation-focused research outputs; (2) enabling environment for research; (3) a brief history of strategy at Wits 1996-2007. These features provide the rationale for using Wits as an in-depth case study covering the period 2003-2013 to articulate a general theory applicable for university research sub-systems of research active universities in emerging economies.

5.3 A decadal overview of knowledge production: Research and innovation at Wits 2003-2013

This overview of research practice at a large research-based university included a high level view of research production, research publishing, and transitions in

these areas of activity. The data was drawn from a review of university annual research reports, faculty research reports and other documents, participant observation, and interviews. In the review period, the case study institution was engaged in research publishing, in creating patentable inventions, in pursuing opportunities for commercialisation of these inventions, and in producing creative works in the fine and dramatic arts. While a decadal view was sought, it was not possible to gain access to statistical data for 2003, as there had been limited curation of this historical data. However, the in-depth case studies of the JCSE and Agincourt research programmes do provide a decadal view of research evolution.

Commencing the institutional review, the data shows that the number of permanent staff by headcount was of similar magnitude across all faculties, Faculty of Engineering and the Built Environment (147), Faculty of Commerce, Law and Management (205), Faculty of Science (212), Faculty of Health Sciences (215), Faculty of Humanities (358) [2012 data]. The data indicates that, using the proxy measure of publications output per permanent academic, academics in the Faculty of Humanities (FoH) were most research productive in 2009 [1.42] compared to other faculties, followed by academics in the Faculty of Science (FoS) [1.3], then the Faculty of Health Sciences (FoHS) [1.14], then the Faculty of Engineering and the Built Environment (FEBE) [0.68], then the Faculty of Commerce, Law and Management (CLM) [0.41]. These ratios changed over the period of study, with the Faculty of Science having the highest ratio in 2012 [1.66].

5.3.1 Practitioner orientation at the Faculty of Commerce, Law and Management

The Faculty has five schools – in the fields of business administration, public and development management, Accountancy, economic and business sciences, and law, as well as six research entities. The Faculty has a relatively low level of research production compared to other faculties at Wits, 0.41 in 2009 and 0.45 in

2012, taking total publications output per permanent academic staff by headcount. A synopsis of research data for the Faculty over a 10-year period is presented in Table 5.1 below.

Table 5.1: Faculty of Commerce, Law and Management research at a glance (2003 – 2012)

	2003	**2006**	**2009**	**2012**
Schools	5	5	5	5
Academic staff permanent (by headcount)	No centralised data (NCD)	180 permanent	177 permanent	205 permanent
A-rated researchers (leading international scholars)	None	None	None	None
NRF rated researchers	None	3	7	18
Number and percentage of academic staff with PhDs	NCD	69 30.5%	83 35.5%	85 33.3%
Research entities	NCD	3	5	6
Centres of Excellence (CoE)	None	None	None	None
Research thrusts or research institutes	None	None	Mandela Institute [law]	Mandela Institute [law]
Research partnerships – South Africa and international	Few, global	Few, global	Few, global	Few, global
DHET total publication output (units)	101.41	98.49 (est.)	73.36	93.97
Graduations postgraduate (research resources): PhD + Masters Dissertation	2 + 7	4 + 4	9 + 2	7 + 8

Sources: *Faculty of CLM, 2013; Faculty of CLM 2007; RIMS 2014; Wits, 2013; Wits, 2011; Wits, 2010; Wits Business Intelligence (BI), 2014; Wits Human Resources (HR) Directorate, 2014; Wits Research Office, 2014*

Research entities are relatively few in this faculty, yet have played a powerful knowledge generation role in society, notably the Centre for Applied Legal Studies and the Centre for Defence and Security Studies. In the 1990's, the Centre for Applied Legal Studies (CALS) was instrumental (in concert with many others) in introducing the theoretical foundations and preparing the documentation for the Interim Constitution and participated in many of the debates pertaining to issues for inclusion in, as well as the legal drafting of, the Constitution of the Republic of South Africa Act, 1996 (participant observer, 1994-1996, no particular incident). Following adoption of the constitution, CALS continued to contribute to the practice of human rights law and law reform (*coded*

as socio-cultural value). The Centre for Defence and Security Studies contributed to the process of establishing the democratic armed forces and civilian policing (*coded as socio-cultural value*). Researchers in the School of Accountancy engaged in a research programme investigating enabling strategies and inhibiting factors for emerging small farmers links with commercial agribusiness for long-term sustainability (*coded as socio-economic value*) (Wits, 2010a, p.95).

Transforming economic sectors, including the agricultural sector, through research-based knowledge inputs is a pursuit strongly associated with the transition to a knowledge-based economy. In South Africa, the complexity of the transformation relates to the socio-political objective of the inclusion of small black farmers in an agricultural sector renewed and revitalised by research-based knowledge. In the five cases related above, the complexity of the research mission can be discerned.

However, no focus areas were selected for investigation from this faculty, due to the relatively low level of research production across the faculty as a whole, as observed by the proxy measure of publications output per permanent academic cited above, and the strong knowledge practitioner, rather than knowledge producer, bias of the faculty. While the complexity of the research mission is common across fields of study, disciplines and faculties, initial observation suggested that there was no major effort to significantly increase the level of research effort in the Faculty of CLM, making this a less appropriate arena for the study of increasing research intensiveness.

5.3.2 Multi-disciplinarity in the Faculty of Engineering and the Built Environment

The seven schools in the faculty were the School of Architecture and Planning; School of Chemical and Metallurgical Engineering; School of Construction Economics and Management; School of Civil and Environmental Engineering; School of Electrical and Information Engineering; School of Mechanical,

Industrial and Aeronautical Engineering; School of Mining Engineering. The Faculty had 27 research entities in 2009 (Wits, 2010a, p.114) and produced 0.68 and 0.83 publications per permanent academic in 2009 and 2012 respectively.

Table 5.2: Faculty of Engineering and Built Environment research at a glance (2003 – 2012)

	2003	**2006**	**2009**	**2012**
Schools	7	7	7	7
Academic staff permanent (by headcount)	NCD	120 permanent	125 permanent	147 permanent
A-rated researchers	NCD	2	3	2
NRF rated researchers	NCD	21	18	28
Number and percentage of academic staff with PhDs	NCD	85 59.4%	87 58.0%	101 55.2%
Research entities	NCD	NCD	27	10
Centres of Excellence (CoE)	No published data available	No published data available	CoE in Strong Materials + National Aerospace CoE	CoE in Strong Materials + National Aerospace CoE
Research thrusts or research institutes	Materials science + engineering thrust established	Materials science and engineering thrust	Cities research thrust; Energy research thrust; Materials science and engineering research thrust	Cities research thrust; Energy research thrust; Materials science and engineering research thrust
Research partnerships – South Africa and international	Extensive, global	Extensive, global	Extensive, global	Extensive, global
DHET total publication output (units)	NCD	NCD	85.24	122.61
Graduations postgraduate (research resources): PhD + Masters Dissertation	14 + 28	13 + 44	21 + 40	28 + 55

Sources: *RIMS, 2014; Wits, 2013; Wits, 2011; Wits, 2010; Wits HR Directorate, 2014;Wits Research Office, 2014*

The multi-disciplinary aspects of engineering research are an important feature of knowledge production in the 21st century. In the period under review, the Biomedical Engineering Research Group worked on "…projects, which bridge the gap between engineering and the quantitative sciences on the one hand, and medicine and the biological sciences on the other…" (Wits, 2010a, p.115) (*coded as values: multi-disciplinarity*). In one example of a patent application filed by Wits, researchers in the School of Chemical and Metallurgical Engineering filed local

and international patent applications for carbon nanotube technology, which has applications in the electronic, biomedical, pharmaceutical and other fields (*coded as commercially relevant value*)(Wits, 2010a, p.127).

Of the many research entities in this faculty, the Joburg Centre for Software Engineering (JCSE) located in the School of Electrical and Information Engineering was selected for the in-depth case study. This research entity was identified for study in 2008 during the early observation phase, because of (i) the institutional complexity related to its early establishment, (ii) its transition to becoming a cross-disciplinary research entity with the capacity to service research in many schools, across faculties, (iii) its capacity building plans for embarking on research in big data analytics, and (iv) its intention to become a knowledge and technology hub in the information engineering and analytical sciences. The JCSE is an important case for understanding the evolution of a new field of research, that of information and software engineering, which is only becoming established in the 21st century.

5.3.3 Faculty of Health Sciences overview and knowledge economy perspective

The Faculty of Health Sciences comprised seven schools, namely the School of Anatomical Sciences, School of Clinical Medicine (consistently the most productive in terms of publication units over several years), School of Oral Health Sciences, School of Pathology (second most productive), School of Physiology, School of Public Health, and the School of Therapeutic Sciences. The most prolific authors in the faculty published between four and 24 scholarly publications per annum, with the most highly cited articles in the period 2002 – 2012 being in the fields of HIV research and cancer research (*coded as high capacity creators of science value for society*) (FHS, 2013). In 2009, 22 health sciences research entities operated in the faculty (Wits, 2010a, p.148). Funding resources for research in the health sciences came from very large donations from international funding trusts, as well as from the South African Medical Research Council, the

National Research Foundation (NRF), the Department of Science and Technology, and through internal university funding sources (*coded as resource capacity*) (FoHS, 2013). Stated goals included "challenging, relevant and innovative research" (*coded as values: promotion of innovation*) (FoHS, 2008).

As demonstrated in the research overview following Table 5.3 below, the health sciences contribution to the knowledge economy is manifested in the socialisation of knowledge to advance human and global health and population development, which is necessary for economic participation and sustainable livelihoods of households.

Table 5.3: Faculty of Health Sciences research statistics at a glance (2003 – 2012)

	2003	**2006**	**2009**	**2012**
Schools	7	7	7	7
Academic staff permanent (by headcount)	No data	203 permanent	202 permanent	215 permanent
A-rated researchers (leading international scholars)	No centralised data (NCD)	3	2	6
NRF rated researchers	NCD	33	51	56
Number and percentage of academic staff with PhDs	NCD	105 52.8%	94 45.2%	105 39.0%
Research entities	NCD	21	23	19
Centres of Excellence (CoE)	No published data available	No published data available	Biomedical TB research (jointly with US and UCT[11])	Biomedical TB research (jointly with US and UCT)+ Antiviral gene therapy + Wits Advanced Drug Delivery Platform
Research thrusts and consortia (companies wholly owned by Wits for supporting commercial engagement)	Wits Health Consortium	Wits Health Consortium	Chronic diseases of lifestyle thrust: An emerging African problem; Molecular biosciences thrust: Health for Africa incorporating the Sydney Brenner Institute of Molecular Biosciences; Wits Health Consortium	Sydney Brenner Institute for Molecular Biosciences (21st Century Research Institute) combines the two research thrusts chronic diseases of lifestyle + molecular biosciences; Wits Health Consortium
Research partnerships – institutions and research councils in South Africa and	No data	No data	Approximately 60	Approximately 60

[11] US is University of Stellenbosch and UCT is University of Cape Town

international				
DHET[12] total publication output (units)	215.44 (FHS, 2008)	202.90 (FHS, 2012)	245.05 (FHS, 2012)	291.33 (FHS, 2012) grew by roughly 43% in 6 years 2006-2012, not accounting for annual fluctuations
Graduations postgraduate: PhD + Masters by Dissertation	16 + 13	13 + 23	19 + 26	30 + 50

Sources: *Faculty of Health Sciences (FoHS), 2013; FoHS, 2012; FoHS, 2010; FoHS, 2008; Health Sciences Research Office, 2011; HSRO website; Wits, 2013; Wits 2011; Wits 2010; Wits Human Resources Directorate, 2014; Wits Research Office, 2014*

Working through the presentations discussed in the four annual research reports for the university 2009 to 2012, a vague sense of the values that underpin research practice and the value created began to emerge, but remained sketchy, due to the absence of explicit commentary on the value of the research performed. The qualitative data reported here presents a perspective on the practice of research in the health sciences. Research on the "unprecedented growth of chronic diseases of lifestyle in Africa" (diabetes, hypertension, obesity, other) (Wits, 2010a, pp. 76-77) illustrated a desire to discover and convey knowledge indigenous (meaning original and particular) to the African continent (*coded as values: promotion of indigenous science*) and highlighted the enormous challenge of making this a reality if a single knowledge dissemination event can reach only 200 people (*coded as social value derived*). The antiviral gene therapy research unit (AGTRU) argued that South African scientists should produce research on gene therapy to avoid reliance on external expertise (*coded as values: promotion of indigenous science*). Its report reflected on the role of the unit in promoting clinical application of its research and commercialisation of its technology for gene silencing to control infectious diseases caused by the Hepatitis B and HIV viruses (*coded as economic value derived*) and its alignment with government's commitment to "developing a knowledge-based economy" (Wits, 2010a, p.150). The Birth to Twenty+ research programme funded by the MRC and the UK Wellcome Trust required a 20-year funding resource flow

[12] DHET is the Department of Higher Education and Training

(Wits, 2010a, pp. 165-168), highlighting the complexity of sustaining funding streams for a single research programme for several decades (*coded as resource sustainability*).

In the course of the grounded theory data collection phases, three groups from the Faculty of Health Sciences came into perspective, illustrating particular insights on research evolution, ways of approaching intellectual property rights and the value of research. These are (i) the School of Clinical Medicine which has evolved the need for data analysis capacity for very large data sets of public health information, referred to in industry literature as "big data" and in the academic environment as data science, which is further discussed in the case study of the JCSE in Chapter 6; (ii) the MRC/Rural Public Health and Health Transitions Research Unit (Agincourt Unit) located in Mpumalanga, the subject of the case study in Chapter 7; and (iii) the Wits Advanced Drug Delivery Platform (WADDP), located in the Department of Pharmacy and Pharmacology in the School of Therapeutic Sciences, one of the subjects of the case study in Chapter 8. The Agincourt Unit was selected because of (i) its location in a rural area and orientation towards knowledge production for rural social development and (ii) its transition from a practitioner orientation to research activeness to research intensiveness. The WADDP was selected because (i) its patent orientation introduces an important practice for university research as a knowledge economy focused endeavour, and (ii) it had the largest number of active patents at the time of selection.

After identification of the case study groups, it was possible to identify particular researchers and to follow their publishing behaviour on the Internet-based open publishing platform ResearchGate. For example, one Wits researcher in the health sciences, whom this author has followed since May 2013, has 102 publications on ResearchGate, 98 of which are journal articles (13 of which are

full-text), and one dataset, all easily downloadable immediately or on request. At the time of the review, this researcher had 135 followers and 300 citations.

5.3.4 Faculty of Humanities raising the prominence of social science in the knowledge economy

The faculty consists of six schools including the Graduate School of Human and Social Sciences; School of Arts; School of Education; School of Human and Community Development; School of Literature, Language and Media; and the School of Social Sciences. While the faculty has a history of high research productivity, in 2009, the schools collectively hosted three research entities, and the faculty hosted the Wits Institute for Social and Economic Research (WISER).

Table 5.4: Faculty of Humanities research statistics at a glance (2003 – 2012)

	2003	**2006**	**2009**	**2012**
Schools	7	7	7	7
Academic staff permanent (by headcount)	No data	303 permanent	324 permanent	358 permanent
A-rated researchers	NCD	1	3	2
NRF rated researchers	NCD	23	24	40
Number and percentage of academic staff with PhDs	No data	184 50.0%	204 44.3%	223 45.1%
Research entities	No published data available	No published data available	No published data available	9
Centres of Excellence (CoE)	None	None	None	None
Research thrusts or research institutes			South Africa – India research thrust through the Centre for Indian Studies in Africa	South Africa – India research thrust through the Centre for Indian Studies in Africa
Research partnerships – institutions and research councils in South Africa and international	Extensive, global	Extensive, global	Extensive, global	Extensive, global
DHET total publication output (units)	120.44	177.54	226.84	260.47 (estimate)
Graduations postgraduate: PhD + Masters by Dissertation	16 + 19	39 + 40	40 + 43	36 + 45

Sources: *Faculty of Humanities, 2013; Wits, 2013; Wits, 2011; Wits, 2010; Wits HR Directorate, 2014; Wits Research Office, 2014*

At the first anniversary event of the Marang Centre for Mathematics and Science education in 2006 (participant observation, 2006), one of the speakers reported on the large number of journal articles published on the subject of maths and science

teaching and bemoaned the lack of access for maths and science teachers to these articles (*coded as hidden value*), which are mostly published under copyright license. While the open access scholarly publishing alternative was not examined in that discussion, it has become an issue for exploration in this research, which is examined in the case study in Chapter 8.

Research enterprise in the faculty included promoting access to knowledge of archaeological findings and living craft with respect to historical African art (*coded as values: promoting indigenous science*) (Wits, 2010a, pp. 184-187). The SARChI research chair in the faculty has built a history archive of the Witwatersrand and is also building the written history of small towns such as Barberton (Mpumalanga province), Mokopane (Limpopo province) and Zeerust (North West province). He argued that (Wits, 2010a, pp.181-182):

> …these areas have been neglected by historians and other academics. There is little in the way of recorded histories of these areas, and they feel intellectually and generally marginalised. In addition, they feel as though their interests are not represented (*coded as values: promoting indigenous science; and coded as socio-cultural value*).

The South Africa-India research thrust located in the Centre for Indian Studies in Africa (CISA) established in 2007, examined issues of transnationalism, important because South Africa has historically attracted populations migrating either voluntarily or by force from many parts of the global south (*coded as socio-cultural value*) (Wits, 2010a, p.85).

While no specific case study focus emerged from the overview of the research of the Faculty of Humanities, the research lead from the Marang anniversary event was influential in the research design with respect to the examination of open access publishing in Chapter 8.

5.3.5 Faculty of Science focus on small and big science

The Faculty of Science has ten schools: the biological sciences cluster included the School of Animal, Plant and Environmental Sciences and the School of Molecular and Cell Biology; the earth sciences cluster included the School of Geography, Archaeology and Environmental Sciences and the School of Geosciences; the mathematical sciences cluster included the School of Computational and Applied Mathematics, the School of Computer Science, the School of Mathematics and the School of Statistics and Actuarial Sciences; while the physical sciences cluster included the School of Chemistry and the School of Physics. The faculty contributed the highest percentage of PhDs amongst the faculties at 36.8% in 2012. The Faculty also produced 30% of DHET-funded publication units in the period 2006 – 2012. In 2009, the ten schools collectively hosted 26 research programmes, research groups, research units and institutes (*coded as institutional complexity*) (Wits, 2010a, p.207; FoS 2013, pp.38-54). Research in the science faculty spanned the domains of industrial economy research fields such as geology, and knowledge economy research fields such as HIV/AIDS drug-related research and nanotechnology to name a few.

Table 5.5: Faculty of Science research statistics at a glance (2003 – 2012)

	2003	**2006**	**2009**	**2012**
Schools	10	10	10	10
Academic staff permanent (by headcount)	NCD	215 permanent	197 permanent	212 permanent
A-rated researchers (leading international scholars)	NCD	6	5	6
NRF rated researchers	NCD	94	94	108
Number and percentage of academic staff with PhDs	No data	180 71.1%	185 69.8%	183 72.6%
Research entities	No published data available	No published data available	26	13
Centres of Excellence (CoE) (DST/NRF awarded)	None	None	None	None – CoE for the Palaeosciences (inter-institutional collaboration) awarded in 2013
Research thrusts or research institutes	No published	No published data	Biodiversity research thrust; Evolution of the	Research thrusts + Bernard Price Institute

	data		species and natural heritage thrust; Mineral resources, exploration and mining thrust; + Bernard Price Institute for Palaeontological Research; Economic Geology Research Institute; Materials Physics Research Institute; Molecular Sciences Research Institute; Rock Art Research Institute; Wits Institute for the Study of the Environment.	for Palaeontological Research; Economic Geology Research Institute; Materials Physics Research Institute; Molecular Sciences Research Institute; Rock Art Research Institute.
Research partnerships – institutions and research councils in South Africa and international	Extensive, global	Extensive, global	Extensive, global	Extensive, global [collaborations across 60 countries, of which 14 African countries]
DHET total publication output (units)	No published data	273.58	258.08	353.52
Graduations postgraduate: PhD + Masters by Dissertation	28 + 38	33 + 39	38 + 70	48 postdocs 63 + 85

Sources: *Faculty of Science, 2013; Faculty of Science 2007; Wits, 2013; Wits, 2011; Wits, 2010; Wits Human Resources Directorate, 2014; Wits Research Office, 2014*

According to the 2013 research report to the URC, publishing and prolific authorship in ISI journals and citations were highly valued in the faculty, as was the high percentage contribution of science authors compared to the university as a whole (approximately 30%). The reasons given for ascribing value to these forms of research production were not explicitly stated nor explicitly related to the value of knowledge to economy, society or to the knowledge base itself.

Engaged in "big science", the School of Physics hosts the DST/NRF Square Kilometre Array (SKA) Research Chair, a global initiative to better understand the universe, dark energy and dark matter and the fundamental laws of physics. The radio-astronomy research will generate a need for big data analysis (*coded as value to science*), in an area of science where very limited capacity exists today at a global level, and where the JCSE based in the Faculty of Engineering is working

to establish indigenous South African capacity (*coded as values: promoting indigenous science*) for big data analytics and data science (participant observation, 2012-2013; JCSE, 2013a), which is explored further in the case study in Chapter 6. The work of the SKA Research Chair on topics in cosmology, extra-galatic astronomy and theoretical astrophysics (amongst other fields) is available on the Internet-based open publishing domain ResearchGate, listing 302 publications of which 297 are journal articles, 254 followers and 569 citations (review 19 February 2014). This open access form of publishing has resulted in 16,280 total publication views, 2,712 total full-text downloads and six total dataset downloads (*coded as values: open science*).

The design of the Nano-Scale Transport Physics Laboratory (NSTPL) in the School of Physics was based on ideas from a local research actor and an international firm (the Janis Research Company Inc) and includes a cryogenic probe station to test electronic devices at low temperatures and high magnetic fields (*coded as global institutional complexity*) (Wits, 2010a, p.219).

In what may be termed "small science", the Economic Geology Research Institute consisted of a very small researcher population, yet through collaboration with other parts of Wits (*coded as values: multi-disciplinarity*), produced significant value in the form of "industry relevant geological data sets" necessary for mineral exploration, without which the cost and viability of opening a mine could not be determined (*coded as values: promoting indigenous science; and coded as commercially relevant value*) (interview Wits-EGRI, 2008). The respondent noted "sticking to our academic values [of academic integrity and research quality] most definitely creates better value in the long term most clearly expressed in our international reputation" (Wits-EGRI respondent, 2008). This data influenced the exploration of values and value as interlocking categories of analysis in the overall case study.

5.4 University level research narrative and environment 2003-2013

Despite the many research achievements of Wits, a 2013 study argues that Wits is at best average in its research performance, when comparing growth in research article production and doctoral and Masters thesis graduates across the top ten universities in South Africa (Mouton, 2013, p.32-33). This is an important issue from the perspective of the broader relevance of this particular thesis, because it implies that Wits has many challenges to face in fostering research intensiveness and it is therefore not a special case in terms of improving research performance. The further implication is that the insights from the thesis research, and the theory generated thereby, would be of interest to a proportion of the 23 South African universities, and to those universities on the African continent and in emerging economies similarly engaged in advancing research activeness.

Here follows a brief presentation of data pertaining to the evolution of research structures and the complexity of building institutional research at Wits. The overview is written in narrative form, interweaving strands from interview conversations, review of Wits annual research reports and the Wits bibliometric analysis of the state of research (Mouton, 2013; key informant Wits-SM1, 2014; key informant Wits-SM3, 2014; Wits, 2009-2013).

In the period from 2003 to 2013, research at Wits shifted through a number of structural forms from research priority areas, programmes, groups and institutes; to research thrusts, entities and URC-recognised research centres; to the co-existence of the latter set with 21st century institutes formed from 2010 onwards (*coded as high impact institutional change*). In the early 2000's, a proposal was made to disestablish the then-existing institutes because the arrangement implied that Wits had effectively committed resources (human, financial, physical infrastructure) to that area in perpetuity (*coded as resource flexibility*). Such long term commitments were not deemed appropriate by some actors, because demand for and interest in research would change over time and long-term

funding commitments would prevent the university from being flexible in its research interests. However, the research institutes were an important pillar in the research architecture at the time, hence the proposed change was not approved (*coded as contestation on research strategy*). This decision advantaged historical entities over new "entrants".

Overlaying these early debates and contestations about research structure, the Wits strategy "Shaping the future" (Wits, 1999) explicitly stated that Wits should establish areas of research strength and consolidate these into flagship programmes. Thus, in 2002, "research thrusts" were established as multi-disciplinary research platforms (*coded as contestation on research strategy*). Research thrusts included themes such as HIV/AIDS research and the study of cities. One of the questions debated then was whether there should be an institute for each particular research thrust, leading to establishment of the Bernard Price Institute for Palaeontological Research, but no institute for environmental sciences. These debates continued throughout the period 2002 to 2010, leading to the co-existence of several structural forms (thrusts, entities, Centres of Excellence as presented under the faculty overviews above) and their gradual evolution (*coded as coevolution of strategy and structure*). New strategies were introduced, including the Wits 2010 strategy, the Wits 2013 strategy and the Wits Vision 2022 strategic framework, each impacting on this co-evolution of strategy and structure.

Towards the end of 2010, university leadership fostered a new strategic approach, arising out of the analysis that the existing institutes were no longer the same in terms of complexity and size (*coded as institutional evolution*). So commenced the motivation for "prestigious institutes" and seven (7) research themes were proposed for consideration by the then DVC Research (*coded as power of actors*). The university conversation finally turned to the notion of 21st century institutes, emulating the idea of the Oxford Martin 21st Century School (Oxford University, UK). More importantly, the conversation arose from the idea

to continue or create institutes (i) whose research pertains to particular global challenges that would shape local and global decision-making in the 21st century (*coded as institutional stereotyping; and coded as institutional evolution*) and (ii) whose work would be organised around research questions aimed at responding to particular local and global challenges and knowledge demands (*coded as values: innovation orientation*).

Six Wits 21st century research institutes were established in 2012-2013, namely The Evolutionary Studies Institute, The City Institute, The Sydney Brenner Institute for Molecular Bioscience, Wits Mining Research Institute, The Global Change and Sustainability Research Institute, and The Institute for Well-being and Development (Wits, n.d.b; Wits n.d.c), all engaged in a special effort to create the next generation of researchers, scientists and academics (*coded as resource capacity building*). The motivation and descriptive documents reviewed reflected on how major research directions are more often fostered by external factors such as funding, and less often fostered by internal choice (Wits, n.d.b, p.2):

> …all of these projects have proved to be nodes of excellence and innovation. However, it is remarkable that few have emerged directly and purposefully from the innovative core of the University – its research. Each has been primarily shaped by other contingent and historical factors, whether these are individual passion, particular funding opportunities or others. How should we address the somewhat "additive" and perhaps even ad hoc nature of these projects and move towards more organic and planned developments. In order to make the best of its unique opportunities, Wits University has identified the strongest of its strategic research areas, and has plans to build them aggressively….

The 21st century institutes were launched amidst some contestation, with at least a few academics expressing concern that the institutes would be large, powerful attractors, drawing funding away from individual researchers and smaller operations in schools, thereby rehearsing the arguments of the mid-2000's (*coded as resource competition*) (generalised participant observation, 2013). It can be argued that the institutes can have a wide range of positive and negative consequences for the larger institution, but they can also offer research leadership

in ways that encourage all research at Wits to more easily gain a 21st century perspective.

Each transition in the formalisation of research structures was accompanied by contestations around funding, as the funding approach changed from a non-competitive historical budgeting process to a competitive process (*coded as resource competition*). To some extent, the competitive resourcing approach changed the culture of funding from what some considered "pet projects" in favour of a more equitable approach, but not more equitable funding (*coded as resource equity*). The top slice from the URC research budget allocated to research institutes and entities increased from 30% to 40%, marginally increasing the resources flowing to research entities as compared to faculties (*coded as resource competition*).

Other challenges experienced in the period 2003 to 2006 involved cultural-intellectual barriers to multi-disciplinary research. Examples cited by one key informant were environmental sciences, HIV/AIDS, and ICT "never worked well because Deans did not want 'their projects' to be hived off "and there was great resistance to cross-disciplinarity which would potentially benefit one school or faculty rather than another (*coded as actor resistance*). Nevertheless, almost a decade later, multi-disciplinarity has strengthened in many spheres as exemplified in the examples of research thrusts presented above and extolled in various research reports from 2009 onwards (*coded as values: multi-disciplinarity*).

The summation of this overview is that research has increased with thousands of actors demonstrating either research activeness or research intensiveness (Mouton, 2013), research structures and governance have evolved, values associated with research are beginning to deepen and expand, heightened value is being achieved and resource flows are increasing. However, this simply sets a greater challenge to the university as the "game of research" appears to have

grown in complexity and contestation to a level of quantum gaming or rapid and continuous paradigmatic jumps that force research actors and the institution to pursue increasingly higher levels of research activity.

5.5 Research resources – infrastructure, financing and people

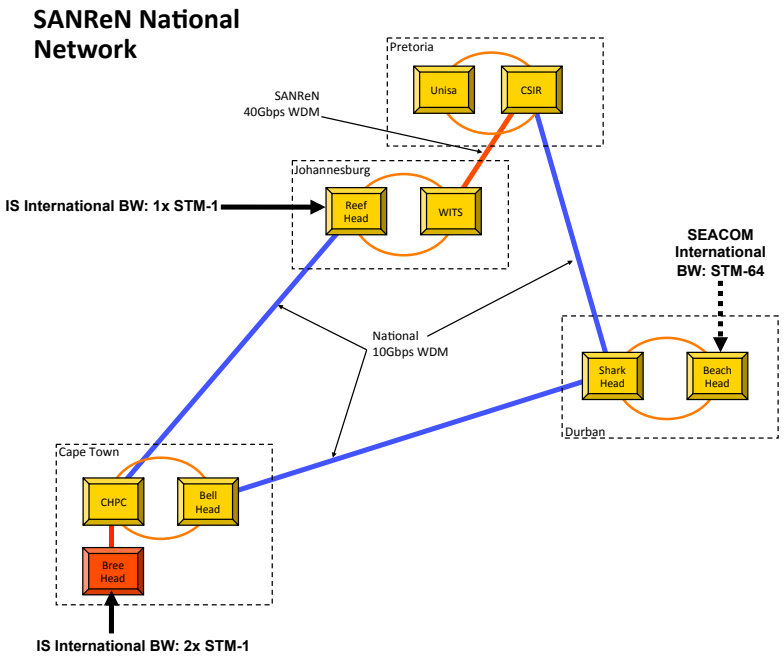
Resources were a visible influence on fostering research at the institutional level of data collection, particularly when manifested as physical research infrastructure. Three key resources are discussed in this section, namely Internet infrastructure (as a particular subset of broader electronic communications infrastructure), financial resources and human resources. Ensuring effective return on investment in high bandwidth Internet infrastructure and related services is relatively complex, with respect to (i) supporting access to vast global electronic libraries of scientific and scholarly publishing, (ii) enabling Wits scholars and postgraduate students to upload their research publications to the web and thus make the research visible to local and international scholars and other knowledge communities, (iii) hosting and making available large data sets for research, and (iv) providing the electronic backbone for a myriad of other research services and uses.

5.5.1 Overview of Internet infrastructure and e-services for research

This section of the narrative is based on review of the TENET website including graphical representation of South African National Research and Education Network (SANReN) usage at Wits, email correspondence and an interview with Wits Central Network Services (Wits-CNS, 2014). Internet infrastructure was introduced to Wits in the early 1990's (circa 1992). The Tertiary Education and Research Network of South Africa (TENET) was established in August 2000 to provide research communications infrastructure to public universities and other institutions in the NSI and has been managing South Africa's national research and education network (NReN) since 2010. NRENs and high bandwidth communications networks operating across economic regions (called RRENs) provide the infrastructure for applications in e-learning, video-conferencing,

hosting and sharing very large data sets in fields such as climate change, health care and radio astronomy. The SANReN connects Wits (see Figure 5.1 below) and other universities to high-speed bandwidth through a 10Gbps broadband ring linking universities in seven cities (*coded as resource complexity*; *coded as high capacity resource supply*). The backbone infrastructure has been extended to small towns with university campuses. Internet and broadband usage has increased exponentially across the university system as "Inbound intercontinental traffic flows on normal working days in the first part of 2013 peaked at over 6 Gbps, which represents a 24-fold increase since October 2009" (*coded as value of communications infrastructure and e-services; and coded as value achieved*) (TENET, n.d.).

Figure 5.1: SANReN link to Wits University



Source: *CSIR Meraka, n.d.*

In full operation, the SANReN will connect more than 204 sites across the country to global research communications networks including the African RREN, UbuntuNet Alliance; the European RREN GÉANT (now GÉANT2); and

the South American RedCLARA, with these research networks hosting over 3,000 research and education organisations across the world (*coded as value defined*) (TENET, n.d.).

Operating through the SANReN infrastructure from 2010 as compared to TENET offerings from 2000, Wits academics and researcher-inventors experienced a significant increase in download and upload speeds, for data sharing and formal collaboration with local and international collaborators, transitioning from access speeds of 73.8Mbps in 2009 to 335.9Mbps in 2010. Wits is a major user of TENET-provided bandwidth and services as per the following statistics (TENET, 2014) (*coded as resource capacity*):

Table 5.6: Statistics for TENET/SANReN bandwidth capacity 2003-2013

	2003	**2006**	**2009-2010**	**2012**	**2013**
Capacity for Wits (unlimited usage)	3.9Mbps	11.6Mbps	73.8Mbps to 335.9Mbps	402.4Mbps	512Mbps

Source: *TENET, 2014*

In its support of academic and student research, the SANReN capacity supported library access to journals hosted on international journal portals such as ScienceDirect; bioinformatics research; a variety of research projects in the School of Physics, including research on the CERN astrophysics and SKA radio-astronomy projects; and numerous other applications (*coded as high capacity resource demand*). According to the responsible academic in bioinformatics (email correspondence, February 2014):

> Wits Bioinformatics is a very heavy user of SANReN for transferring large data sets, both public data sets that are mirrored here, or data sets that our biologists generate and are sequenced elsewhere (most cases). Here we are talking of data in the 100s of GB size. Decent network speed is crucial. For many of our research meetings we used the Adobe Connect system, which is a service run by SANReN. We coordinate several projects using this, which we generally find more reliable than Skype. I also help the Physics ATLAS group and run the Tier 3

ATLAS site at Wits. We run 100s of jobs from all over the world and there is regular transfer of data.

Three examples

- Recent download of a 80GB genotyping data set from the sequencing centre at the University of California at Davis. We had sent DNA from 200 participants in the Birth to Twenty project for genotyping, which they had done and we then downloaded the data set from them for analysis. This is part of a much bigger project but this specific data will be used to explore for genetic factors implicated in diabetes and obesity in black South African populations. For each participant, we have approximately 200k SNPs — i.e., the genomic variants that the individuals have at 200 000 positions on the genome. We have several data sets of this sort.
- We keep a mirror of the Protein Data Bank (http://www.rcsb.org/pdb/home/home.do). This is a very large database of 3D protein structures as resolved experimentally using X-ray crystallography and NMR. This has about 180GB of data currently. For about 80000 proteins, this database records the relative position of each atom in the protein. An application of this would be drug design.
- Gene expression data: this is usually RNA extracted from cells and sequenced. This would be used to explore which genes are active and at what level. A good example of this sort of problem is the work…trying to understand what genes are implicated in making certain variants of cassava resistant to drought or virus.

The CERN project had its own dedicated capacity at 10Mbps. As more researchers seek capacity for more research applications, Central Network Services (CNS) will need to increase the overall capacity purchased, possibly increasing from around 400Mbps to around 600Mbps (Wits-CNS key informant, 24 February, 2014) (*coded as value of ICT research infrastructure*; *coded as high capacity resource demand [ultra-broadband]*). Thinking about provision of ultra-broadband may appear unrealistic in the South African context, however, the demand for big data analytics in the health sciences, as well as in research in physics and space science is rapidly moving demand from gigabytes to terabytes.

The TENET Board of Directors provides the governance for the NREN including seeking donor funding and deciding the level of contributions from member institutions (*coded as institutions: governance complexity*). TENET sees the future as

being to shift from mere infrastructure provision to value-added services provision, which could include "…high quality videoconferencing; and the establishment of trust federations in which many institutions agree to provide each others' staff and students with access to each others' electronic resources…" (*coded as value of communications infrastructure and e-services*) (TENET, n.d.). Each of the 23 South African universities have contributed in the region of ZAR5m per annum for six years 2009-2014 (some universities for a shorter time), as an investment in part ownership of the Seacom undersea cable infrastructure at a cost of approximately ZAR690 million. TENET is not viewed as a sustainable business in the long run and some universities including Wits have proposed that government take over the operation and subsidise the cost to operate (Wits-CNS, 2014). The question arises how universities will participate in the future governance of SANReN and the quality of governance at a state owned enterprise as compared to a not for profit organisation (*coded as institutional risk of good governance*).

5.5.2 ICT infrastructure and e-learning services

The Wits e-learning operation eLSI (e-Learning, Support and Innovation) utilised the SANReN for its services to academics and students (Wits-CNS, 2014). For several years, eLSI has made applications available to conduct collaborative lectures and research engagements with students and academics at universities on the African and other continents (*coded as resource utilisation*). Under-utilisation of resources was expressed as a concern, as translating capacity or availability into usage involves time lags and culture transformation (*coded as values: institutional innovation*) (Wits-eLSI, 2014).

Wits has struggled to take advantage of the bandwidth capacity available for e-learning. In a 2007 report, the authors stated that (SAIDE, 2007):

> The University of the Witwatersrand (Wits) presents an interesting case-study of another kind of 'operational' approach to e-Learning, concerned primarily with technology and minimally with pedagogy. Wits has settled, apparently more by

> accident than design, for a blended learning approach in which ICTs are used to supplement traditional face-to-face interactions. Overall, computer-mediated learning is not very widespread in the university. Wits does however provide a rich ICT environment for students...

This analysis was still largely true in 2014, where eLSI was engaged in providing infrastructure and support services, not in mapping the terrain of e-learning, illustrating the challenge of utilisation and institutional culture (*coded as institutional innovation*). According to the key informant (Wits-eLSI, 2014), Wits has not consistently explored ways of introducing, mapping and advancing e-learning for teaching and e-learning for research, indicating the lack of an experimental environment (*coded as institutional innovation: missed opportunity*). The key informant quoted the lone ranger model (Bates & Sangra, 2011) with respect to introducing e-learning and argued that lone rangers get noticed and encouraged by peers and seniors, but the lone ranger find its too exhausting to fight against institutional culture for an extended period. The key informant quoted the example of a particular academic using Moodle, then the whole department using Moodle, accompanied by failure to persuade the university to use Moodle, resulting in lack of integration, a tendency towards chaos, until a more strategic direction emerges (*coded as contestation of values and value; and coded as institutional chaos*).

The utilisation of e-learning as a continuum of learning and utilising tools for research, with both formal and informal dimensions, is not yet practiced in the university. For example, this key informant observed that interactive media opportunities explored by postgraduate students included moocs (massive open online courses), whereby clusters of expertise form and postgraduate students were recognised for their expertise and started to interact with each other. Students working in personal learning environments were co-contributors to a mooc and "there are many kinds of moocs, such as c-moocs (constructivist moocs) dealing with messy problems" (Wits-eLSI, 2014). eLSI did not set this up

intentionally, but created the ecology for moocs to develop (*coded as socio-cultural value achieved*). The challenge was to develop ways to prompt this ecology to develop and turn into something sustainable, for example creating integration between personal learning environments and the formal learning environment (*coded as unrealised value*).

> Its about a 21st century way of following knowledge, typically university students are not yet primed to follow knowledge. Universities are very uncomfortable about undergraduate students following knowledge from networks because of the assumption that the lecturer must be the guide to knowledge not the network. There has been real opposition to this – at seminars about open access resources management have stated they are offended by this notion because the experts are housed at Wits (Wits-eLSI, 2014).

The reluctance to embrace 21st century research and teaching methods, may be based on the experience that the model used to become experts is individualistic, thus individual expertise is at war with the ease of access to the universe of expertise. "The contestation is about whose knowledge is the de facto accepted knowledge – those questions have always been around, but networks are intensifying those questions because of multiplicity of voices" (Wits-eLSI, 2014). This is auspicious of strategy battles still to come, namely what constitutes the scholarly identity in the 21st century (*coded as contestation of academic values old and new*).

One of the values that eLSI ascribed to was openness, in terms of open learning resources. For example, by introducing Sakai, eLSI was able to benefit from and contribute to software code to improve Sakai (*coded as values: openness*). Openness was not seen to fit very neatly with the university's values system. Nevertheless, because of the relative importance that e-learning platforms and services have gained, the university transferred eLSI's annual cost from external funding to the University Council budget from 2014 (Wits-eLSI, 2014, confirmed by participant observation at Senate ICT Reference Committee, 12 February 2014).

5.6 Institutional strategy and research strategy as resources: In two parts

5.6.1 A brief history of strategy at Wits

The Wits strategic plan released in June 1999, titled *Shaping the Future* sets out several goals (i) increasing the proportion of post-graduates; (ii) improving the volume and quality of research, attracting post-doctoral researchers, developing young researchers and access to electronic publications; (iii) partnerships with other tertiary institutions, industry and commerce, government, NGOs and civil society; (iv) positioning Wits as an internationally recognised university; and building an academic community reflecting South Africa's calibre and diversity of people; and (v) creating an attractive learning environment with due regard to infrastructure and facilities, and to the issues of gender, race and cultural diversity (Wits, 1999). The strategy introduced an epistemological break for Wits, elements of a new democracy-facing paradigm in higher education. Although the language and objectives were mainly cast in the paradigm of excellence in teaching and research, it also introduced the concept of mode 2 science, more typical of a knowledge economy strategic paradigm. It did not describe or set itself fully within a knowledge economy paradigm, but picked up on a few key points, inter alia, ICT as an enabler of universities operating in real and virtual space. The strategy could be interpreted as emerging thinking about the South African university in the knowledge economy. This period may also have heralded an epistemological break for universities across South Africa, when the language of the knowledge economy began to enter the strategic documents of higher education institutions, although the White Paper for Science and Technology (DST, 1996) had already flagged the discourse earlier on.

The language of the strategy document is vague, noting that Wits must be "traditional and transitional", operate in "an increasingly global framework for higher education", and take note of "new forms of knowledge production and

transmission" (Wits, 1999, p.1). Reviewing the 1999 strategic document (and the 2002 version of Shaping the Future), from the perspective of 2007, raised the question whether in practice Wits had incorporated the traditional, the transitional and the new forms of knowledge production and transmission into its institutional life. These issues are explored in the case study.

In 2005, Senate adopted the Wits 2010 Strategy titled *A University to Call Our Own*. The university vision was adumbrated as follows (Wits, 2005):

> A future focus, … is one in which we commit to ensuring that higher education is viewed not as a peripheral luxury but rather as a vital element of social, political and economic development. … Wits will move in a determined manner towards making a measureable contribution to the development of a more equitable, productive and engaged future. Thus, by 2010 Wits should be recognised internationally as a leading South African university in terms of its current contribution to knowledge, democracy, intellectual leadership and economic development. Excellence in our core activities of teaching and learning, research and engagement will be indisputable.

The recurrent themes of excellence and social engagement/responsibility were restated, however, an explicit reference was made to "contribution to economic development". This represented an apparent shift in thinking about the concept of academic and service excellence to include a concept of utilitarianism that was focused on economic interventions. In the period 1996 to 2007, a progression of ideas and practices gave rise to a state where the direction was set for a strong research focus, high throughput, funding and advancement, and new forms of university relationships with government and industry.

The Wits leadership strategic retreat in November 2007 represented one of the moments for entrenching the conversation about Wits aim to become a "top 100" or research-intensive university (observation incident 2, November 2007). At this event, no mention was made of universities as institutions participating in the knowledge economy; rather the focus of the conversation was on the progress of specific schools and how to address their challenges in ways that would enable

the component schools of the university to make greater progress towards the top 100 goal. The top 100 conversation continued for many years and "top 100" was translated as "leading world-class research intensive university" in the Wits 2013 strategy and the Wits Vision 2022 strategic framework. This conversation placed a strong influence on strategic planning in the university, virtually substituting for any conversation about the role and positioning of universities as research producers in knowledge-based economies. But the two are not wholly dissimilar conversations (generalised participant observation 2007-2013; key informant Wits-SM3, 2014), as the focus of the Wits strategic planning conversation was on research production and new forms of institution building for research production (Wits, 2005; Wits, 2010b; Wits 2010c).

The Wits strategic research plan 2007-2011 (Wits, 2007b) addressed the challenge of becoming a "research-driven university". It emphasised producing "nationally and internationally recognised work", publication in leading journals, developing postgraduate research and publication, making teaching and learning research driven (Wits, 2007b, p.3). The value of being research-driven, to the university and to society, was expressed as contributing to enlightenment; to approaches to national and regional development; to participation in university-industry-government-civil society partnerships; to fostering the next generation of researchers, educators and innovators; as well as to enhancing the capacities, resources and reputation of the university. The values (termed principles in the document) (Wits, 2007b, pp. 3-4), expressed the desire for research excellence; for research impact through extending the "frontiers of knowledge"; for academic freedom and institutional autonomy; for consolidating research strengths; for inter-institutional and cross-disciplinary research collaboration and engagement with the research audience; for an enabling research environment; and for financial sustainability of research.

The language of the document was relatively technocratic in strategy terms, articulating seven (7) goals, of which the first goal defines the expectations of being "research active". Such research activeness included the primary task of consistent scholarly publishing on an annual basis with a preference for Thomson Reuters/Web of Science publications (indicated as ISI), and the secondary task of meeting any one of the following measures – attracting an external research grant, *or* attracting external research income of more than ZAR100,000 in five years, *or* supervision of at least one postgraduate student to completion in five years, *or* producing an additional three scholarly publications in five years, *or* being granted an NRF rating.

The primary research task immediately engaged the academic in an international competition to get published, while the secondary tasks presented a wide choice. In combination, these tasks were a good proxy for being research active, but they were also a good proxy for a high level of complexity in research performance. According to the 2007 strategic plan, an academic who published a combination of five refereed books, book chapters, journal articles (preferably ISI), or conference papers in five years and supervised only one postgraduate student would qualify as research active. The inference can be drawn that trade-offs among the primary and secondary tasks would enable most academics to meet the requirement to be research active, however this would have to be tested.

The 2007 strategic research plan defined a research active academic, but did not define a "research intensive" or "research complex" academic actor. It is postulated here that focusing attention on being research active is not sufficiently strategy oriented, because it does not get to grips with the complexity of being a research-intensive actor or becoming a research-intensive institution. The strategic research plan included a brief commentary on the distinction between real quality and proxies for quality (such as ISI publications and citations), but no strategic reflection on how to approach the challenge of making research quality

real. The document offered qualitative data on the complexities pertaining to actors (*each staff member becoming a research active individual*), the institution (*a list of indicators of success including a high number of rated researchers and 50% of staff to have PhDs, to mention two*), resources (*financing was the main resource highlighted*), values (*set out as principles variously related to notions of excellence*) and value (*benefits of knowledge to society*).

Being research active in terms of the 2007 characterisation of activeness in the research strategy simply produced activeness, but did little to enable a transition to a "leading world-class research intensive university" as foreseen in the Wits 2013 strategy and the Wits Vision 2022 strategic framework, or as would be required for operating as a knowledge intensive research producer for an emergent knowledge economy. Aiming at research intensiveness would indicate the requirement for a very high functioning complement of academic and administrative staff, where the actors are constantly advancing the research game plan.

Another of the highly contested issues in the conversation was (and remains) the contested meaning of actor or institutional or knowledge "engagement", alternatively the "form and context" of engagement and the relationship of engagement to "community", discussed in a presentation to the conference on Public Health Education in a Globalised World (Ballim, 2008). He noted (Ballim, 2008, p. 1):

> Tensions between the "core" activities of the university (teaching, learning and research) and community engagement can sometime seem irreconcilable and may lead to an institutional culture that merely tolerates community engagement – as an unpleasant necessity brought about by internal or external political pressure – but only deserving of being on the periphery…

The paper raised many debates about what forms of community engagement are relevant and appropriate to the research university, noting that "…social problems do not fit with academic disciplines" (Ballim, 2008, pp.2-3), the latter

point suggesting the need for multi-disciplinary approaches to social problem-solving, but not explicating advancing the case. The paper gave an indication of the complexity that may be encountered by academic actors when pursuing their own localised forms of engagement with communities, testing and finding out for themselves whether these forms of engagement lead to increased research productivity, or increased value for the institution and the community, or both productivity and value.

At various points in the period 2008 to 2011, Wits institutional leadership expressed interest in particular phenomena common to the literature on universities in the knowledge economy, notably the phenomenon of the triple helix relationship between university-industry-government as described by Etzkowitz and Leydesdorff (2000). Specific presentations and discussions took place at a Wits Strategic Planning and Allocation of Resources Committee (Wits SPARC) meeting (participant observation incident 4, 2008), but many of these exploratory conversations did not progress or mature. Inductive reasoning suggests that triple helix relationships form at the level of the specific knowledge production process, for example software development services to industry with research funding from government, not at the level of formal institutional leadership.

The next set of institutional and research strategies, *Wits Vision 2022 strategic framework* and *Wits 2013 Strategy* set a stronger tone for research productivity, driving a strong institutional positioning towards research and internationalisation through research and postgraduate studies. Emphasis was laid on evidence-led monitoring of the performance and positioning of the institution, including the state of research (Mouton, 2013) (*coded as values: self-reflection*). Written in the same era, these latter strategy documents showed strengths and limitations, herewith a few excerpts and associated comments (Wits, 2010b; Wits, 2010c):

Table 5.7 Commentary on strategic positioning of the case study institution

Statement from Wits strategy document	Commentary
(i) "…task to safeguard our reputation and aggressively enhance our international recognition as a research intensive university"	What does this mean? Superficially it means high quality research and lots of it, but how this idea translates into strategy is not clear
(ii) "Our renewed commitment to internationalization and development of teaching and learning, and research infrastructure is one way of expressing our firm belief in academic and research excellence, and rigorous public engagement at Wits"	Some sentences, like this one, lack internal coherence and sound like putting together university related jargon in a single sentence.
(iii) "global standards of academic and research excellence"	The meaning of "global standards" and "research excellence" is not stated
(iv) "success founded on values that we are not willing to compromise on" (Wits, 2010c, p. 10)	Why not, is the relevance of these values not self-evident? Is there a threat to these values? What is the nature of the threat?
(v) "full support of the University community"	An old-fashioned idea in strategy terms, perhaps what is needed is contestation so that the strength of ideas and approaches is continuously tested
(vi) "significance of this University as part of the national research and innovation system"	The idea of being part of a broader knowledge creating system begins to enter the discourse of university leadership
(vii) "leading research-intensive university firmly embedded in the top 100 world universities by 2022" (Wits, 2010b, p.2 and various other documents)…"as a proxy for world class excellence" (Wits, 2010b, p.3)	Why the push for research status? What does this fraternity offer that is valuable – if the university is in this fraternity, then what has it become – why is top 300 of approx. 20,000 not good enough, why top 100 – what is it about the top 100 that the university seeks? The 20th century was largely about massification of higher education, the 21st century is about universities as research-based knowledge producers and innovators, is that it? Are there other, better proxies for excellence?
(viii) "quantum leap advantage to further position itself as an undisputed internationally leading research intensive university" (Wits, 2010b, p.2)	Gaining a quantum leap advantage would require a substantial part of the institution to be engaged in quantum research games with multiple levels of difficulty. Is this the case?

The values statement listed the following values (Wits, 2010c, p.11): independent enquiry and trust; international engagement; intellectual excellence and integrity; academic freedom and institutional autonomy; collegiality; social engagement and responsiveness; diversity; accountability; debate and critical engagement. There is nothing wrong with these values, but many of them are at least a few centuries old and new values have begun to emerge in the 21st century, but these are not explicitly expressed as values, for example multi-disciplinarity.

The final document to introduce briefly is the Wits research strategic plan 2012-2017, (Wits, 2012b), which is explicitly linked to Wits Vision 2022. In this document, ideas about the knowledge and innovation as drivers of change, the national innovation system and the Africa-urban context, the development of research capacity, 21st century institutes, increased research quality and impact, contract research, prioritising open access publishing were more fully formed than in all previous strategy documents.

5.6.2 Strategy intentions and real world finances

Wits set out to achieve greater research output of local value and global impact. A review of what was achieved in the period 2003 to 2013 (Mouton, 2013; Wits-SM3, 2014; Wits, 2010d) revealed some limitations in the mechanisms to tackle these goals and gave a sense of great potential for research and innovation, constrained by resources, values and actors. When introducing new strategies, institutions are caught in structural constraints whereby the existing resource flows, values and actors are focused on the old strategy and no new mechanisms have yet been designed to encourage or foster the new strategy. Thus, at Wits, resource flow, values and actors were focused towards a steady state of research publication, as evidenced in the Mouton (2013, p.83) report – 1074 journal articles in 2007 and 1384 in 2011, rather than towards a heightened state of research production (*coded as institutional strategy limitations*). Mechanisms to advance towards such a heightened state would require significant change in the resource

flows, values and actor dispositions towards research. Moreover, there is a perceptible time lag between the adoption of new strategy, the pursuance of greater research intensiveness pursuant to the strategy and visibility in terms of research publication and other research outcomes. Let us examine a few of the existing mechanisms, resource flows, values and actor dispositions.

An important mechanism aimed at fostering the strategy was the Wits SPARC fund, relatively small in comparison to the size of annual research funding from historical sources, therefore providing limited leverage to turn the proverbial corner. The challenge with Wits SPARC was that few agenda items moved beyond discussion mode into tangible and meaningful initiatives. For example, despite the open access (OA) publishing workshop held in November 2012 and the signing of the Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities at a SPARC gathering, in 2014 there has been no university policy on how to promote and fund OA. Reasons for the failure to produce the new mechanisms timeously can be inferred to relate to change in leadership, or change of understanding of the issues involved, or inability to effectively capture the specific areas of work in senior management portfolios, or lack of resources, or a combination of these factors (*coded as adaptability of actors*). It was understood that Wits SPARC was a place where (Wits-SM3, 2014):

> the strategy could be shredded into different parts that could be funded and resources channelled there…managed to do that by putting in place budget panel for discussing questions about what different faculties and units were doing but (we) did not have an abundance of resources…extra supplemental sources of income are needed to implement strategy since the Council budget is inadequate and the university did not have the time to grapple with the idea of accessing funding for strategy implementation as opposed to the day to day teaching, research and administration.…what happens after we funded the (Wits) SPARC projects and we realise that these projects are supporting the strategy, we are not pursuing these ideas systematically.

A rough estimate suggested the need to raise a ZAR100 million endowment fund for implementation of the 2022 strategic framework, but there are few easily

accessible external funding streams that would support this fund size. In the period 2008 to 2013 fundraising was locked into infrastructure and other capital projects, rather than strategy implementation, because government provided a large infrastructure budget and universities had to come up with matching infrastructure funds, focusing attention away from research strategy. Fundraising also focused on the six 21st century institutes, so a few components of the strategy were funded (*coded as values: intangibility of strategy*).

The total R&D expenditure at Wits over the eight-year period 2005 to 2012 is largely illustrative due to the difficulty of assigning financial value to research activities and infrastructure using Frascati manual data categories. The data shows a doubling of research expenditure in 2012 as compared to 2005, see Table 5.7 below. Despite these being estimated values, the data showed total R&D expenditure of close to a billion rand in 2011, high relative to the estimated ZAR20 billion rand gross domestic expenditure on R&D recorded for the 2009/10 and 2010/11 years of reporting (*coded as high capacity resource supply*) (DST, 2013, p.2). The total estimated 8-year spend on R&D was ZAR4,539,426 or ZAR4.5 billion.

Table 5.8: Total Wits R&D expenditure 2005-2012

2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
ZAR'000	ZAR'000	ZAR'000	ZAR'000	ZAR'000	ZAR'000	ZAR'000	ZAR'000
409 786	386 033	534 984	43 086[13]	466 054	778 683	949 102	971 698

Source: *Wits Frascati reports to HSRC CeSTII, 2005 to 2012*

The culture of institutions and actors plays a critical role in how the university translates strategy into action. Wits was observed to have a culture of robust engagement and actors would get stuck in that mode and re-rehearse the intellectual conversations, rather than exhausting the arguments and

[13] Information for 2008 and 2009 is incomplete

implementing research strategy so that the future debates would be about what has been done and what change has ensued (*coded as values: socio-cultural inhibitors*).

5.7 Analytical remarks

Despite the obstacles described here, Wits was observed to be a vastly different organisation in 2013 than in 2003, with a focus on staying abreast of the most advanced aspects of local and global research problems. Possible reasons cited by the key informant lie in the "most hated but most cited slogan of the top 100" and the coincidence of two apparently opposing paradigms, which engendered a sense of direction at an institutional level (Wits-SM3, 2014). This direction emerged through contradictory rather than mutually supportive forces. In the one paradigm, a sufficiently large number of the Wits academic community really wanted to be engaged in international research because of strategic interest and were assessing themselves to see whether they fit with Wits requirements for research activeness as a proxy for global achievement. On the other hand, the institutional paradigm was to compete for international recognition and to push the institution towards a ranking among the top 100 universities. These two paradigms became mutually reinforcing because it meant that Wits would fund what academics wanted to do anyway, pushing people and resources in the same direction (*coded as values: coinciding paradigms*).

This focus on being in the top league of universities had several detractors, both internally and externally. There was some frustration with pursuing the goal, because of mixed messages from society regarding the challenges of meeting socio-economic needs and national imperatives argued by government to provide medical doctors, scarce skills, large numbers of black and women graduates (*coded as contesting paradigms*). There was a significant investment of time and effort in teaching to live up to these societal expectations, yet the aspiration was towards research, which is time consuming and may appear to be

at the cost of teaching (Wits-SM3, 2014). However, the shift in the last decade may have been the gradual realisation by internal and external stakeholders that research produced at Wits can be valuable to society. So academics kept pushing against adversity, because there was capacity and desire to achieve top performance, both in terms of national needs and global status (*coded as resolve of actors*).

Reflecting on external influences, when it submitted its annual enrolment plans, Wits was still asked why it was shifting to postgraduate students when there were so many students who needed undergraduate degrees (Wits-SM3, 2014). Despite references to fostering a knowledge-based economy in science and technology policy, this view was not strongly represented in higher education policy, not even in the most recent White Paper on Post-school Education and Training (Department of Higher Education and Training, 2013). The push for producing graduates for an industrial and services-based economy did not explicitly acknowledge the need to also produce graduates for a knowledge-based economy, thereby placing significant stress on the fostering of academic research due to limitations in the enabling environment (*coded as limitations of actors*).

Despite the policy weaknesses, increased demand for research production and publication has led to some academics seizing the funding opportunity for publishing in ISI journals, while others have been observed to feel defeated (*coded as dissimilar behaviour of actors*). This divided response has led to requests for differentiated forms of employment contract for emphasis on research or teaching, suggesting the need for differentiation within the university (*coded as differentiation among actors*). Such differentiation may lead to new forms of contestation about the interpretation of the value of teaching and the value of research, though this lies in the future (*coded as institutional futurism*).

5.8 Chapter summation: Hints of entanglement

The chapter produces a perspective of a high degree of entanglement in complex processes, of research universities as highly entangled institutions, not merely complex institutions. Complexity theory discusses difficulty and risk, but does not get to grasp with the particular fractal nature of universities. In this study, the fractals are coded as actors, institutions, resources, values and value and an attempt is made in the ensuing chapters to understand each in some depth, as well as the inter-relationship among these elements and their effect on entanglement. The data presented in the chapter reveals high levels of complexity in fostering university research activeness, but also reveals curiosity and strategic interest.

This trajectory of developments provides insight into Wits as an institution in its own right, as well as insight into the workings of a large research-active university in South Africa and possibly therefore insight into similar universities in other emerging knowledge economies. While each university will have its own story to tell, the research-active universities are likely to tread a similar path, each interested in the other's evolution. This discussion provides the rationale for arguing that an in-depth study of Wits University over the period 2003 to 2013, using case study and grounded theory methodologies can provide insights and relevant theory for research universities in emerging economies.

5.9 Segue to in-depth case studies

Pertaining to the choice of case studies that follow in the next three chapters, many options arose for the particular choice of case studies, including the actors and institutions referred to in this university level overview chapter, for example research on the Square Kilometre Array radio telescope; or research on society, work and development; or a study of the Gauteng City-Region Observatory; or

the challenges of becoming Wits Commercial Enterprise. However, only five case studies were chosen for in depth study, for the reasons set out in each case below.

The University of the Witwatersrand (Wits) has seen the growth of research through the creation of many new research centres in the past decade, including the Joburg Centre for Software Engineering (JCSE), which promotes quality assurance for the local software industry. The Wits Rural Facility, situated 500km from the main Wits campus includes seven rural-focused research programmes, including the Agincourt Health and Population Unit, which has strengths in both public health advocacy and in research publishing.

Chapter 6 Case study B: Evolution to a nascent tech hub: Positioning the Joburg Centre for Software Engineering

The case studies narrated here cascade out of the grounded methodological approach to the discovery and building of theory. The case study chapters are structured and written in such a way as to identify the main category of theory (research entanglement in universities) and the related sub-categories that emerged from the data collection. Particular sub-categories emerged from each case study at different points in time and are therefore discussed in each particular chapter. Data collection led to theorisation, which then guided further data collection for the same or another case study. The case studies were then reviewed collectively to ascertain the common sub-categories. Five common sub-categories emerged, namely actors, institutions, resources, values and value.

Each of the initiatives investigated in the five case studies presented in this thesis encountered significant difficulty in coming into being and are illustrative of the kinds of complexity and adversity encountered by actors and institutions, under particular resource constraints, operating within particular value systems and striving to achieve particular forms of value. In the case study of the Joburg Centre for Software Engineering (JCSE) that follows, the difficulties highlighted include actors who contested the initiatives to produce R&D and explored applications innovation; an institution that was only just learning the importance of university-partner balance; and debate on whether values of industry engagement are compatible with achieving academic value.

The case of the JCSE was selected because software engineering is a young science as compared to traditional sciences such as history or geology, even newer than genetics, and the actors engaged in pursuing this research mission faced the challenge of attracting institutional support and resources for the initiative from a zero funding base. The formative years of the JCSE and its

research and related training endeavours suggested a study opportunity which could produce the kind of data needed to analyse and understand the dimensions of university change in the emerging knowledge economy.

Software engineering is a field of knowledge development where applications are written for services offered in an electronic communications environment, whether applications for computing, for broadcasting, for mobile cellular communications or for Internet-based communications in any service sector, including banking, health services or defence and security applications. In the past 30 years, software engineering has moved from being written in backrooms and garage workshops, to being produced by large firms such as Google, to sitting at the heart of knowledge intensive R&D in the broad services sector. The quality of software is an important factor in its value to users and its market value.

This first case study was prepared using data collection methods of participant observation and note taking over the period 2002 to 2014 as the researcher participated in selected meetings of the JCSE, university workshops, meetings of the Tech-in-Braam working group, and preparation of discussion documents on building data science at Wits. In addition, there was extensive document review of annual reports and proposals for the period 2011 to 2014, website review, email discussion review and unstructured interviews with four key informants during 2008 and 2014.

6.1 Evolution of software development capacity building through the Joburg Centre for Software Engineering

Evolutionary development of institutions appears to be quite as much a case of survival of the fittest as evolutionary development of the species.

6.1.1 From thinking to concept to contract to centre: 1990-2004

This section of the narrative was written based on data from interviews in 2008 and 2014, from participant observation incidents between 2008 and 2013, and from a review of institutional documents (secondary sources) for the period 2010-2013.

The origins of the JCSE date back to 1990 with early discussions on where ICT should be located in the post-modern university. In the 1990-91 Wits model, ICT was located across three faculties with little collaboration and with different cultures and ideas of computing: telecommunications, data processing, signal processing and electronics in the engineering faculty, computer science and information systems in the science faculty, and information systems management in the commerce faculty (key informant JCSE-S) (*coded as institutional design*). A single engineering academic was engaged in cross-disciplinary research on software process and quality in an era where cross-disciplinary work and industry engagement was frowned upon. Despite a merger proposal for computer science and information engineering presented by the Dean of Science in 1989, no coherent entity was established to populate this emerging field of knowledge, even as technological and services convergence advanced. This split approach (*coded as institutional fracture*) created some degree of confusion in the marketplace about how industry and students should relate to Wits offerings (JCSE-S, 2014):

> This fracture continues to this day…. By 2002, there was some interest in starting a software research centre, because of strong and continuing linkages with and research sponsors from industry…The idea of creating a "front end" to ICT led to proposal to establish the JCSE as a strong industry-facing centre that could present a coherent face to industry.

The initial proposal to Senate was rejected, as were several further proposals, partly because of the desire for a "no change" environment (*coded as actor contestation*).

The actors from engineering were regarded as too close to industry and there appears to have been a lack of understanding of the very different type of knowledge being pursued in software engineering as compared to computer science. Indeed, it can be argued that the discipline of software engineering is entirely connected with industry and has limited reason to exist outside of industry applications, just as mining research has limited value outside a mining applications context and health sciences research has limited value outside a health applications context. These knowledges cannot grow in any significant depth outside an applications context, establishing demand for a different form or medium of knowledge than research publications (*coded as values: contestation of knowledges*).

Despite rejection of the proposals by Senate, a business plan was written for establishment of the "gateway centre", because the City of Joburg metropolitan municipality sought to profile Johannesburg as a software hub as part of its city development programme. However, stakeholders consulted on the business plan did not want such a centre as previous initiatives (iLab) had not been successful and had created no value in the market. A few software suppliers and users argued for creation of a centre that promoted better quality software development, cementing the formative idea of the JCSE. Further university-industry discussions and pre-funding from the municipality led to Senate approval of the Centre in 2004 and a formal contract with the City of Joburg (*coded as coincidence of interests of actors*). A review of best practice in software engineering led the main actors to a key report produced for the Department of Trade and Industry (the dti), namely the SAITIS[14] report (the dti, 2000), which exposed the weaknesses in the local software sector as related to skills and performance. The report provided the foundational thinking for what came later at the JCSE, setting out a detailed ICT sector development framework (*coded as coincidence of interests of institutions*).

[14] SAITIS is the South African Information Technology Industry Study

While the conversation with Wits and the City of Joburg was maturing, the Gartner group advised Wits that it was important to work with a CMMI level 4 or 5 rated company to develop the Oracle student software information system. Tata Consulting Services (TCS), rated at level 5, became engaged in this work, resulting in a visit to TCS India operations in 2004, the flow of events influencing the early agenda of the JCSE towards building a South African CMMI training programme, still offered in 2014 (*coded as coincidence of the interests of institutions*).

6.1 2 Early years of the JCSE: Laying foundations and developing internal capacity 2005–2011

This section of the narrative was pieced together from foundation interviews in 2008, a review of documents published between 2010 and 2013, as well as a review of the JCSE website. Publications where this researcher is the first co-author are cited.

The JCSE was launched in May 2005. A relationship was established with TCS India and separately with Carnegie Mellon University for the purposes of CMMI (Capability Maturity Model Integration) training to advance software innovation in South Africa (*coded as global institutional linkages*). The Advisory Board was constituted in 2005 and early relationships were established with the first funding partners, including the City of Joburg, Vodacom, Microsoft and other software firms (*coded as local institutional linkages*). It was essential to unlock industry funding since no university funding was available, only space and use of Wits facilities. Funding was very limited at the inception of the JCSE – Microsoft and IBM each funded a software lab, offering only equipment, not money. Under these relatively open conditions, both proprietary and open source software interests were established at the JCSE and opened the door to other partners coming on board. The only partner who put in significant funding in the early days was First National Bank (FNB), because of their need for skills

(*coded as resource availability*). Initial financial inputs were relatively small, thus development of the centre was relatively slow.

A Director was appointed in 2006 and international relationships with Carnegie Mellon and TCS began to mature with the establishment of local CMMI training capacity. However, money was needed to train trainers and JCSE attracted funding of ZAR1.6million from the dti enabling it to create the CMMI programme, teaching and certifying local trainers, consultants and appraisers, which increased income flows. The focus advanced to growing income through Master classes, a CMMI conference, forums and industry events (*coded as resource generation*).

The JCSE had five founding principles, some traditional university values and some not (*coded as values: non-traditional*), namely to support the software industry through promoting best practice in the African context; to grow skills and capacity; to support transformation of the sector race and gender profiles; to participate in trade missions with the Export Council; to make available applied research including the annual skills survey; and to promote innovation and incubation. Industry promotion and applied research are not highly regarded at Wits, though the reasons are vague. At the early stage of grounded theory data collection, the following insights emerged (JCSE-S; Abrahams & FitzGerald, 2012, p.7):

> If we bought all our software from (Sakai), ... we become a client to someone else's way of doing things. If your cell phone talks to you in Sotho, you are more engaged in that technology'…However, there is resistance to the existence of such a centre at a university, '...if you look at the (institution's) values you find things about engaging in the broader society..... if I talk to Microsoft that's perceived as something you shouldn't do because they're the commercial demon. That stuff devalues what I'm doing against a perceived purity that it's too commercial, too engaged.

Despite university resistance to the values of heightened industry engagement, by 2013, the JCSE had programmes against each of its five espoused principles (*coded as values: explicating new values*).

From 2007, the emphasis was on getting the JCSE footprint into industry. Public relations activities, press releases, dissemination of an annual report and marketing messages, and attending trade shows started to push the identity of the centre, which started to have some visibility, but was still operating on a shoestring budget. The research focus developed from 2008, initially through the production of the annual skills survey, which was influential in industry because it identified the top skills priorities on an annual basis, and was the only available research to identify the size of the sector, the skills profile and the skills gap (JCSE, 2010). The centre developed high visibility in the banking sector, the software sector and the government IT sector, leading to increased income earnings (*coded as academic value*). The JCSE had to match expenditure with income, as the two main founding partners, the City of Joburg and Wits were insistent that the centre operated on a zero deficit business model. The upside of this agreement was that if the centre earned its own income, in theory it would not be at risk of withdrawals of grants. The downside was that (JCSE-RS, 2014):

> …if we were a business, we would have access to other means such as selling equity or getting loans, but we don't have access to mechanisms that businesses use, so we can only operate through once-off grants from business and government (and income from training), so a lot of time is spent on looking at ways to get injections of money. Writing proposals is very time consuming, managing agreements, and managing non-payment…no deficit but hardly any profit.

But finances did come, including ZAR5.4 million from the dti to do Team Software methodologies, the next step in the CMMI framework. The JCSE grew its annual income from under a million rand in 2004 to ZAR24.3 million in 2012 (JCSE, 2013a).

6.2 Advancing through software engineering and prospects for data science

Why did the team keep going? The team was oriented against failure; it believed in the potential of the South African IT industry to develop, to create significant knowledge-intensive economic activity and employment; it chose to " fight for the industry and make it a success" (JCSE-RS, 2014).

6.2.1 Maturation of JCSE: Developing sector capacity and cross-disciplinary research integration 2011-2014

Having laid the institutional foundations, the JCSE developed a range of capacity building and research foci, of which some initiatives are discussed below.

Innovation focus 1: JCSE values innovation in knowledge and understands the three (3) constituent elements of digital technology as software, hardware and content.

This focus is on knowledge production and commercialisation. The data presented here was collected through a review of annual reports of the JCSE for 2011-2012 and 2012-2013, website review, interviews with external parties and a group interview with researcher-advocates.

JCSE's High Maturity Programme aims to promote software development through establishing software development units that have high levels of predictability and quality in the design process. The first hi-mat unit was established in 2013, developing grid-computing software for smart metering. The standard set for these hi-mat units was to better the current industry benchmarks to produce software within 10% of the scheduled date, within 5% of allocated budget, having 0.5 defects per 1000 lines of code (*coded as value: innovation promotion*). The programme has brought global process improvement models including CMMI to South African industry and has eight Masters and PhD students under supervision (website review: JCSE, n.d.a) (*coded as value: scientific research capacity building; coded as value: innovation capacity building*)

The Microsoft Windows 8 App Factory operates from the JCSE's Tshimologong Precinct on the perimeter of Joburg's inner city, because Microsoft wants a non-commercial environment in which to situate their young development teams, where a quiet environment and concentration productivity is required. Interns are building apps for the Windows app market, to catch up with Android and others, while also driving the local Windows 8 platform adoption by building apps with local relevance for the local market. The App Factory had a 3-tier skills development structure, commencing at tier 1 by training interns to build software based on their own ideas and develop basic skills and capabilities (low complexity apps which fit the skills level of new interns), then moving to tier 2 training interns in the design of medium complexity apps to interact with services such as the Rea Vaya information service for the local bus rapid transport system, finally moving to tier 3 where high level skills are needed to design high complexity apps, such as the News24 app (hundreds of thousands of users) or the IEC app (millions of users) (*coded as resources: skills development for innovation*). Microsoft aimed to replicate this app factory mechanism in other African countries, so the particular app factory was an incubator of ideas for future replication.

The knowledge exchange with the JCSE was logical for the app factory, which needed to reside in a software community, enabling partnership and cross-pollination of ideas through lectures and knowledge sharing discussions. The App factory software developers collaborated with the JCSE software development team, the interns building apps and the JCSE doing complementary backend software development (*coded as values: collaborative innovation*).
The Microsoft team leader discussed the App Factory experience as creating locally relevant value, for example the What's App application for local events in South Africa, the Transnet carbon app, which enabled the user to compare road and rail usage, the LeadSA app, and the South African Airways app. Apps were regarded as creating value for both the South African and global markets (*coded*

as value: economic innovation). Other value gained was skills for the interns to create their own businesses or find a job

Innovation focus 2: The JCSE values innovation in software usage and impact on the university, economy and society.

This focus is on producing knowledge impact. A project in which social value was achieved was the design and development of a case management system (CMS) for the Legal Resources Centre (LRC), a not-for-profit human rights law service for vulnerable and marginalised people (*coded as value: social innovation*). The LRC provides legal services in circumstances where the cases are precedent setting for communities who cannot afford private legal services. A specific case was that of *Centre for Child Law and Seven Others v Government of the Eastern Cape Province and Others*, in which an out of court settlement was reached for government to provide formal infrastructure to the so-called "mud schools" (Skelton, 2013). The LRC needed to account to donors and therefore needed "a diligent system to account for the number of hours spent on each case file and the associated funding" (key informant JCSE-LRC, 2014). Within LRC, different tiers of professionals each charge at different rates. The case management system (CMS) had two functions (i) it allowed transparency of time at work and the cost thereof and (ii) it was an excellent repository of information on each specific case with the capability to draw reports on specific beneficiaries. The fact that the CMS was based in the cloud allowed LRC staff significant flexibility, as they could access the system from any Internet access point.

The system was designed in collaboration between LRC and the JCSE and more than 20 Masters students gained valuable experience from the concept, design and rollout of the initial system. The value to beneficiaries was having a single point of storage for all case files and an advanced information system. The values of client confidentiality and access to legal justice become enshrined in the CMS. Presenting donors with good information about community benefit from the

LRC programme was important to attracting greater donor funding to service community needs (*coded as social value*).

6.2.2 Formation of cross-disciplinary research linkages: Initiating data science research

During 2012 to 2013, the JCSE explored the opportunities for establishing a data science research institute, as a means to "contribute to the body of academic knowledge in the field of big data and data analytics" (JCSE, 2013a, p.6). Early ideas about practicing data science originated from the collaborative working relationship between the JCSE and Wits Bioinformatics, followed by discussions with IBM about building capacity for data science and other capacity building, followed by a workshop with Wits academics to explore interest in using data science capacity and participating in capacity building (participant observation incident 7, 2012), followed by meetings to identify which Wits academics had the keenest interest in using data science. In this process, some of the keen users were identified as those from Wits biomedical informatics, the Institute for Wellbeing and Development (data science services to the Birth-to-Twenty programme and the Agincourt Unit), the astrophysics and cosmology group at the Wits School of Physics (Meerkat/SKA programme), as well as a number of the Wits 21st century institutes including the Sydney Brenner Institute for Molecular Bioscience (bioinformatics processing capacity), the Wits City Institute (dataset management, 3D rendering, virtual archiving, other), the Gauteng City Region Observatory (accessible storage for spatial data in the cloud), and the Wits Mining Research Institute (large amounts of seismic data, accurate spatial representation of seismic records, other) (*coded as value: massive data science capacity; and coded as value: innovation promotion*) (JCSE, n.d.b).

The formal proposal to establish a data science institute (JCSE, 2013b) was presented at a few faculty meetings in preparation for presentation to Senate, who would either support or reject the proposal. The undercurrent of opposition

to the 21st century institutes was maturing and the plan for a proposal for a seventh institute would have needed to carry some considerable support from faculties prior to presentation to Senate. The presentation to the Health Sciences faculty meeting in September 2013 raised sufficient queries and opposition to suggest an alternative approach to building data science, other than proposing a new institute (*coded as actors: opposition*) (email conversation, 30 September 2013):

> The proposal is amorphous….what exactly will the institute do what are its aims … goals too generic what will the actual work be…. need to refer to other examples for models… document must be shorter … must be simplified …. must clearly show alignment with existing programmes….

Thus, the JCSE actors and collaborating parts of the institution chose to proceed with building data science research, rather than building an institute (*coded as actors: response to adversity*).

6.2.3 Innovation capacity development focus: IBM capacity development prospects 2012-2014

This data was collected from participant observation in meetings with IBM, Wits researchers and CSIR Meraka staff held at the CSIR in mid-2012, several meetings held at Wits in 2012 and 2013, a meeting with IBM and the Department of Trade and Industry at IBM offices in Sandton in 2013, and a small group interview conducted in 2014.

IBM and the JCSE had a common interest in ICT sector capacity building. IBM's intention was to make a ZAR100 million investment in ICT sector capacity building. Meetings and discussions took place between Wits and IBM towards establishing three-year multi-disciplinary undergraduate engineering and ICT programme and a postgraduate Skills Development and Research Institute (SDRI). In February 2013, a meeting with the dti was hosted at IBM premises in Sandton, with presentations aimed at winning government support (participant observation incident 10, 2014). A long silence followed the presentation day, during which the IBM project champion left the company. The initiative

continued in a state of go-don't go! The next steps were not yet clear, including whether Wits (JCSE) was the preferred partner institution.

6.2.4 Digital technology hub development 1: Tech-in-Braam software development cluster 2012-2013

This data is drawn from participant observation from selected Tuesday afternoon meetings of the Tech-in-Braam cluster (16h00-18h00) in late 2012 and a presentation to the partnerships workshop held at Wits on 16 April 2013.

Participants in the Tech-in-Braam[15] digital technology cluster had a broad set of interests and objectives beyond designing software applications (*coded as values: conscious co-creation of 21st century knowledge*). Goals of the participating organisations (including ThoughtWorks, Microsoft, Crunchyard, gaming software expert and others) focus on increasing the number of digital technology practitioners, creating jobs for digital technology professionals and promoting digital technology businesses (participant observation incidents 8, 2012; website review, Tech-in-Braam, n.d.). The main challenge was to draw software companies from their traditional locations in the upper price end locations, to Braamfontein to co-locate with the JCSE's digital development capacity building and research programmes. This was an unusual challenge, as there has been little history of geographical co-location of industry programmes with universities in South Africa (*coded as institutional attractiveness*).

The presentation to the April 2013 partnerships workshop made the case for Braamfontein to be Africa's software cluster as follows: Gauteng province contributed 40% to South Africa's GDP (actually closer to 35%), most of this contribution to GDP being generated within a 10km radius with Braamfontein close to the centre of that circle. The flight of capital from the central business district of Johannesburg was not complete and was reversing, with major

[15] Short for technology in Braamfontein

corporations, government and trade unions still focused in the centre of Johannesburg. All these sectors required software and digital content, thus being potential customers for the software applications (apps) development sector.

The University of Johannesburg and Wits would provide an attractive university for young, mobile, creative people from across Africa seeking to enter the software development sector, drawn to the mobile city and surrounds, supported by 21st century transport infrastructure such as the urban connectors Gautrain and the Rea Vaya bus rapid transport system. At this workshop the plan was advanced to establish a software innovation precinct for meetings and events; skills development; innovation and new tech start-ups; less formal spaces for generating content at no charge; and more formal curated, rented, co-working spaces; Microsoft App Factory; skills programme for the banking sector; hi-maturity software development unit; games and digital content hub with the Wits Digital Arts programme; short courses and night schools; schools programme for Grade 9 kids; CoachLab skills development and leadership programme for postgraduate students from UJ and Wits; and to place anchor tenants engaged in technology pre-incubation and incubation in the digital technology hub. The plan unfolded to repurpose dilapidated buildings in Braamfontein to establish Tshimologong Precinct, to introduce municipal broadband to the kerb and to attract '150' software companies and associated service companies to foster a Braamfontein software innovation cluster.

One of the responses to the presentation commented that the ideas reflected on the university as urban development agency (participant observation incident 11, 2013), and a discussion ensued among participants about university investment parallel to local government's city regeneration strategy. Thus the accumulated resources and investments of the city, local business and the university were seen to come together as the foundation for attracting firms to participate in a software

innovation cluster (*coded as future value*). The software innovation cluster has been active since 2014.

6.3 Co-evolution of scientific knowledge production with location

6.3.1 Digital technology hub development 2: Tshimologong Precinct, Braamfontein 2013-2014: Between university and city

This data was collected from generalised participant observation in several meetings during the course of 2013 and 2014, from participant observation and review of the presentations at the Founder's Event held at the iClub at Tshimologong Precinct on 31 October 2013, as well as from semi-structured interviews.

The process towards creating a "place of new beginnings[16]", a "set of spaces" including collaborative working (co-working) spaces commenced in mid-2013, with approvals required from Wits to upgrade the facilities for habitation of the first set of buildings in the new precinct. Despite difficulty in confirming budget and plans for the initial rehabilitation phase, events and public seminars were held in the gutted nightclub (Tshimologong precinct introduction evening 2012; Founders' Event 31 October 2013; music concerts; Internet Society Gauteng meeting; and public seminar on the ICT Green Paper, 2014). These events influenced budget availability and the first buildings were occupied in January 2014, providing space for approximately 20 young developers of the Microsoft App Factory, and meeting rooms for formal meetings and Saturday postgraduate research seminars (*coded as academic value*).

[16] Tshimologong is a seSotho word whose English translation is best evoked as "the place of new beginnings"

6.3.2 With the university but not in the university

The influences on creation of the Tshimologong Precinct included internal influences (the specific needs of the JCSE/LINK/Digital Arts tenants and ideas about needs for co-working space) and external influences (visits by founding institutions JCSE and LINK to similar hubs including the iHub in Nairobi, Kenya; Silicon Roundabout/Tech City in London's East End; the Cambridge Innovation Centre, Kendall Square, Cambridge, Massachusetts; 22@Barcelona Innovation District, Poblenou, Barcelona; The Open at Maboneng Precinct in Jeppestown in downtown Johannesburg). The intention of the precinct development was to move beyond the perimeter of the existing campuses and to merge into the city space where the place of new beginnings becomes a metaphor for connecting into the knowledge projects of the emerging software applications sector (JCSE) and studying the consequent economic and societal value (LINK Centre) (*coded as social innovation focus; coded as economic innovation focus*).

The establishment of the university ICT knowledge precinct was connected with the urban change occurring in Braamfontein, the repurposing of the decaying inner city for a new generation of university students and knowledge workers (*coded as co-evolution of social and economic innovation*). This inner city revitalisation, as opposed to gentrification, includes simple, low-cost, ergonomic workspaces (ThoughtWorks); student and visitor community spaces (Southpoint student centre and the Saturday Neighbour Goods Market); coffee shops, bars and eating places; street trade and small shops selling retro goods or contemporary fashion; and is a space for public art. This was important data to enable interpretation of the value of this location for the precinct in socio-economic development terms, because Johannesburg has historically had limited attractiveness in terms of its urban culture compared to the coastal city of Cape Town, being essentially a place of work and a service-oriented culture.

The revitalisation of the century old urban infrastructure in Braamfontein and Jeppestown has occurred side-by-side with a shift in urban culture, linked to new forms of knowledge production, what has been referred to as "the evolving reality of a vision toward a shared urban future, through the metamorphosis of the city's existing space economy" (Kotzen, 2012).

6.3.3 Creating collaborative working space

The collaborative working spaces at Tshimologong are housed in an open walk-through space; with other spaces converted into offices, meeting spaces, training rooms, computer labs, space for the CoachLab project and temporary co-working space for the Microsoft Windows 8 App Factory occupied from January 2014. Plans presented at the Founders' Event in October 2013 were for the creation of Tshimologong as a living lab, "an exemplar of sustainable building and urban design strategies and solutions in a post-carbon world" (JCSE, 2013c), including installation of processes for solar energy, water harvesting, an urban food garden and waste recycling on the rooftops – a so-called "green gantry" (*coded as values: innovation orientation; sustainable urban design; inner city renewal*).

Numerous actors and institutions were engaged in the conceptualisation, design and development process, including the heads of the JCSE, LINK Centre and Digital Arts; Wits maintenance division; Wits capital infrastructure projects division; the economic development unit of the City of Joburg metropolitan government; Microsoft, ABSA and FNB as users and funders; postgraduate students; and many others. A significant level of chaos was prevalent on a daily basis as the physical infrastructure needs, capacity building and innovation needs constantly clashed in a concert of activity, generally with productive outcomes, often creating significant hurdles to success (*coded as institutional complexity*).

6.4 Retrospective from the supporting actors

The context to the eventual establishment of the JCSE offers important data for the purpose of theory building. A member of Wits senior management recalls the process of establishing the JCSE thus (key informant Wits-SM1, 2014):

The proposal for an ICT research thrust was based on ICT being listed as one of 12 sectors for which technology foresight reports had been prepared in the National Research and Technology Foresight project 2020 (DACST, 1999), based on sector working groups and Delphi surveys. It was thus considered a "no brainer" to promote an ICT research focus. However, there was contestation between open source software advocates and industry oriented software advocates, which delayed the approval of the centre. External influences also came to bear on the complexity associated with establishment of the JCSE. The university was engaged in discussion with the software firm Tata Consulting Services (TCS) and became interested in its association with the Indian institutes of technology for ICT (IIITs) and the value gained for both university and industry from this relationship. This led to a Wits study visit to the IIITs to understand how Tata was supporting the IIITs in India. This visit was a crucial turning point in the decision to approve the establishment of the JCSE as a university research centre, as the observation of the real-world operation of the IIITs gave greater specificity to the idea of an ICT research thrust and greater clarity to the potential outcomes from the proposals to establish a software engineering centre at Wits. Once clarity was gained, the barriers to establishment of the JCSE appeared to disintegrate. However, new obstacles would emerge at various stages of the game that would have to be navigated and negotiated (*coded as innovation orientation*).

University-government-industry partnerships remained a difficult terrain of development. The first JCSE partnership, with the City of Joburg, took time to receive support from university management, who expressed concern that the

governance of the entity by a board constituted primarily of industry and government would put governance in the hands of external actors. It was emphasised that the entity should operate within the realm of Wits institutional policy and that governance body would have powers of recommendation only. Strong contrary views were expressed. In order to facilitate a resolution, the Wits Legal Office drafted the constitution of the centre and the contract between Wits University and the City of Joburg, addressing those issues that constituted real difficulties for Wits (*coded as contestation of interests of actors*).

In the same period, other university partnerships were coming into being, such as the partnership with the Gauteng provincial government for operation of the Maropeng hominid site museum. A new partnership philosophy was emerging from the experience of actors working on the formalisation of university partnerships with government and industry, expressed as a general view along the following lines (Wits-SM1): an academic institution entering into partnership with other entities as part of its strategy, which is not coerced but enters into partnership in order to achieve its own goals, should be prepared to temper some of its requirements, because it can't impose absolute conditions on its partner(s). This view influenced the relative ease with which such partnerships would be accepted in the future. In the case of the JCSE, the approach of university management softened towards promoting a balance of interests, rather than attempting to keep the interests of the university dominant (*coded as coincidence of interests of actors*).

6.5 Insights for theory building from the case study of the JCSE

The evolution of the JCSE and its R&D mission can be described as a quantum innovation game, with multiple players playing multiple games of significant levels of difficulty at the same time, in ways that constantly interweave with each other. The probability of losing any particular game or component of a game (such as competing for financial resources) appears to be low, but the win occurs

over the very long term. The probability of winning the objective over a quantum set of games appears to be high. In its formative years, the JCSE was an entity providing training and certification foundations to foster innovation, though it fostered the idea of becoming an R&D entity. The shift from training and certification to include R&D took approximately ten years from 2004 to the installation of the software development collaborative working spaces in 2014.

The challenges experienced had an alternatively stimulating and frustrating effect on the actors, as the resource and institutional challenges faced on a daily basis were daunting, and there were often disagreements amongst key actors, with support being less forthcoming than critique. This affected the preparedness of the proponents of the new research directions to continue in this state of adversity. However, the data reveals that the research actors and the university too, are driven by curiosity and strategic interest, as much as by the attraction of complexity and adversity. Analytically speaking, universities are not often thought of by those engaged in academic life as untrodden frontiers of the universe, such as prospecting in the plains of Greenland where the terrain is dangerous and the contest with nature is skewed against the prospectors. Yet, prospecting for knowledge in the brief interludes of openness in the university is not wholly dissimilar from prospecting for rubies in the two brief months of an Alaskan summer.

Inductive reasoning suggests a few ways of thinking about the lessons from the JCSE case study:

(a) Actors (when the interests of actors coincide, when actors are open to external influences, when actors exhibit a keenness and ability to play quantum games that have a high degree of difficulty, they tend towards a successful new positioning of their institutional segment).

(b) Institutions (when the interests of actors and institutions coincide, when the mutual interests of separate institutions enable a vision of the future, institutions lean towards favourable outcomes and away from stunted growth).
(c) Resources (where the level of difficulty of getting access to resources is great and actors risk their reputations to acquire resources, there is a high probability of ensuing resource flows).
(d) Values (where there is explicit identification of values with the age of rapid innovation, there is a high probability that displaying such values will lead to participation in quantum games).
(e) Value (making value explicit requires participation in quantum games that have a high level of difficulty; when actual or potential value becomes visible, then actors and institutions often support the initiative, even if only partially or under duress).

What do we learn about entanglement from this data and analysis: This component of the case study did not raise the concept of entanglement, nor did it elevate that concept to the level of theory. Entanglement arose out of the open access component of the case study and has been applied retroactively to the other two case study components, JCSE and Agincourt, because it was observed to be the core category that relates to each of the sub-categories. Using inductive reasoning, this case study component has enabled the researcher to identify the categories of actors, institutions, resources, values and value, that form the foundational elements of the theory to be expounded in the later chapters.

Chapter 7 Case study C: Evolution of a 21st century research institute: Community knowledge research facility at the Agincourt Health and Population Unit, Bushbuckridge, Mpumalanga

The MRC[17]/Wits Rural Public Health and Health Transitions Research Unit (Agincourt Health and Population Unit) is institutionally located in the School of Public Health at Wits University. Its physical location is in Bushbuckridge Local Municipality in rural Mpumalanga province, some distance from the Mozambican border. The objective of the Agincourt-based research programme is to provide longitudinal surveillance of critical health challenges and associated changes occurring over time for vulnerable, rural communities, to feed this data back to communities and into public policy processes, as well as to build complex longitudinal data sets that can be interpreted and reinterpreted from the perspective of health, demographic and social transitions. Hence, this case study focuses on science as social innovation. The Agincourt research programme commenced in 1992 and the research unit received MRC recognition in 2002 (Agincourt, n.d., Wits, 2009a).

In 2007, when this researcher first encountered the Agincourt Health and Population Unit, it was loosely aligned to the Wits Rural Facility (WRF) [located outside the town of Acornhoek on the road to the Orpen Gate of the Kruger National Park], with its research management site in the small town of Agincourt. This chapter examines the particularities of the Agincourt Health and Population Unit and its evolution, in order to better understand the process of evolution to increasing knowledge intensity. This entity became of particular interest during the course of the grounded theory research because of its remoteness from the main university in Johannesburg, its history of community engagement and contestation with university leadership on its scientific versus activist engagement, as well as its co-existence with other research groups at Wits

[17] MRC = Medical Research Council

Rural Facility at a time when Wits was considering building a more advanced research programme there. Of the many research initiatives encountered at Wits University, each with its particular history and characteristics of evolution, the Agincourt work and project history brought a rural, non-industrial dimension to the broad subject of study.

This second case study was prepared using notes from a site visit to Wits Rural Facility in 2007, document review and semi-structured interviews with three key informants in relation to the Agincourt Health and Population Unit in 2008, and review of the Wits Rural Observatory business case document in 2009. Further data was collected from Wits annual research reports for the period 2009 to 2012, and the Faculty of Health Sciences biennial research reviews for 2008-09 and 2010-11. The data collection process was completed in 2013-2014 through review of earlier email discussions with key informants from 2008, review of the entity's website, review of published research articles which set out the history and value of the project, and a visit to the Agincourt research site on 11 March 2014, during which the researcher conducted three unstructured interviews, visited a number of villages, as well as the Kildare Clinic in Kildare Village and the Bhubezi Community Health Care Centre. The narrative below weaves together data pertaining to the actors, institutions, resources, values and value that emerged from these data collection processes.

7.1 The rural location and context of research at Wits Rural Facility and Agincourt

Wits Rural Facility came into being in 1992 following a 350-hectare land grant at Acornhoek by Anglo-American mining company (Wits, 2009, pp. 5 & 13). Acornhoek is an area of 39km^2 in the Bushbuckridge local municipality in the northeast of Mpumalanga, and has a population of 33,529, with Tsonga, Northern Sotho and Tshangaan the most spoken languages (StatsSA, 2011). The community included South African, Ethiopian, Malian, Mozambican, Pakistani

and Zimbabwean populations, with Ethiopian, Pakistani and South African restaurants in Acornhoek. The research office at Agincourt, see Figure 7.1 below, is approximately 40km from the Wits Rural Facility. Agincourt village, about 8.5km^2 in area, has a population of approximately 5,000 mainly Tsonga-speaking people (StatsSA, 2011). Important knowledge challenges for South Africa reflected by the knowledge needs of the Bushbuckridge village communities, include health issues pertaining to chronic communicable and non-communicable diseases, population development, environmental and natural resource management, and public education (observation incident 16, 2014) (*coded as value: social demand*).

Figure 7.1 Location of Agincourt study site



Source: *Agincourt Health and Population Unit, n.d.*

Given the remoteness of these villages from concentrated economic activity and from provincial hubs of social investment, many socio-economic development challenges exist for communities, for institutions, for local, provincial and

national government including challenges of poorly resourced basic health care, for example immunisation and anti-retroviral therapy. The demand for public knowledge for development purposes is greater than the supply (*coded as supply and demand of knowledge*) (observation incident 16, 2014).

7.2 Formulating a case for knowledge infrastructure investment at WRF

Wits University had made some relatively basic financial investments in research infrastructure and accommodation for scientists at the Acornhoek WRF during the 1990s. By 2007 the investment had run its course and research infrastructure, Internet access and accommodation, needed a new phase of investment (Wits, 2009b). Internet access was slow and paid for by academics themselves (Wits-RKH, 2014), quite unsuitable for researchers working at a remote site from their institution, from cities or towns, and from access to online resources. The entities located at WRF are generally engaged in evidence-based research and advocacy for rural development, partly in order to address gaps in knowledge and partly to inform public policy-making (Wits, 2009b, p. 9-10). The main research areas at WRF are health and environment focused, in particular "health, population and social transitions; the impact of HIV/AIDS; the relationship between rural populations and natural resources; competing claims for natural resources and the identification of alternative resource use options" (Wits, 2009b, p.15).

In 2007 to 2008, Wits Rural Facility evoked the interest of university leadership, because it demonstrated reasonable research capability including increasing publication rates, and it presented an opportunity to position the university in rural research. Given the foundations laid by the erstwhile research programmes and the infrastructural weaknesses identified, the university embarked on a review of the Wits Rural Facility in order to explore the potential for transforming the rural facility into a rural studies research institute (Wits, 2009b). The formal review of WRF titled *Establishing the Wits Rural Observatory, A Rural Sciences Institute: Business Case* proposed a transition from an evolutionary period

1992-2008 in which five research and public education programmes had emerged (Agincourt, SUNRAE[18], RADAR[19], Competing Claims[20] and GEMP) to a multidisciplinary period 2009-2020 in which the health, population and environmental research would constitute inter-dependent programmes of research forming a rural sciences institute, aiming to attract scholars and students, new research projects, strengthen relationships with the local community, civil society and government, and participate in academic, African and international outreach (Wits, 2009b, p.iii). Efforts were invested with respect to funding for the proposed institute, which led to a new period of infrastructure investment from 2014, as the basis for a new phase of rural-focused research (*coded as resources: knowledge infrastructure investment*).

7.3 Contestation over values and value at WRF/Agincourt

In a 2008 interview (key informant Wits-SM2, 2008), a member of the university senior management team commented on one of the important values understood to inform the work of the research teams at the Wits Rural Facility, namely academic engagement with society, though the nature of that academic engagement was contested. It was argued that, in the 1990s, the academics at WRF lacked an understanding of whether they were activists in a non-governmental organisation (NGO) or scientists at a research facility. The academics were seen to be "light" on academic values, and immersed in the community environment. The university critique of an "alternative science" culture aimed at problem solving (in environmental development) was possibly inaccurate, as the case quoted appears to have been an instance of poor research design, rather than alternative science, noting that science as problem-solving is precisely the approach being adopted to position the work of the 21st century institutes in 2013-2014. Much of the early contestation (*coded as contestation of values*) appears to have been a face-off regarding the virtues and appropriateness

[18] Sustaining Natural Resources in African Ecosystems
[19] Rural Aids and Development Action Research
[20] Competing Claims on Natural Resources Programme

of being an NGO or being an academic entity, based on interpretation of the interview with Wits-SM2 (2008).

The Agincourt researchers explained that the work of their programme held both social and academic value from the onset (key informants AHPU-S1/2, 2008). The social value was derived from the analysis of the longitudinal data collected from the annual local health and population census and the health policy insights communicated to government and communities (*coded as value: socially beneficial knowledge*) (Wits, 2009a, p.69):

> The lack of vital health information of the world's poorest communities, which experience the greatest burden of disease is a severe impediment to developing effective health policies and programmes. Research needs to be both relevant and accessible to key stakeholders and this is an important area of responsibility within our programme.

The academic value was derived from the capacity to provide a platform for South African and international academics to conduct rural health research, leading to the formation of an international rural health research platform, the INDEPTH network and the publication and wide dissemination of research data (*coded as value: academically beneficial value*). In 2008, a visiting academic from Virginia was quoted as commenting on the value of the facility being in such close proximity to Wits, as in the United States a researcher would "have to fly for two days in both directions (example Sri Lanka) to get access to a place like this" (AHPU-S1/2, 2008). As featured in the Wits annual research report for 2008 (Wits, 2009a, p.69):

> We believe strongly in building a community of scholars with diverse experience - our projects offer this opportunity. The work is complex, providing ongoing stimulation for quality doctoral studies embedded in existing research projects.

As research became more institutionalised and the annual publication count increased, the relationship with the main university body changed. In particular, publications from the Agincourt programme grew from 3 publications in 1992 to 77 publications in 2013, see Table 7.1 below. The international value of such

scholarly publishing was recognised with the production of a special open access edition of the *Scandinavian Journal of Public Health* on the subject of "Health, population and social transitions in rural South Africa" guest edited by Agincourt academics, which reported on 15 years of "social transitions underway in rural post-apartheid South Africa" (FoHS, 2010). Other publications appeared as open access journal articles, including the article Profile: Agincourt health and socio-demographic surveillance system published in the *International Journal of Epidemiology* in 2012. Scepticism on the part of university leadership was slowly replaced by acceptance, partly because Agincourt came to resemble the university more, rather than because there was a better understanding of the values informing Agincourt's growing value to society and the university (*coded as relationship of values and value*) (Abrahams & FitzGerald, 2012).

Table 7.1 Agincourt unit scholarly publications per annum 1992-2013

Year	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Publications	3	2	4	1	0	3	5	8	6

Year	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**
Publications	9	5	2	11	6	11	34	16	16

Year	**2010**	**2011**	**2012**	**2013**
Publications	33	43	45	77

Source: *Agincourt unit, email correspondence, 6 December 2011 and 20 March 2014*

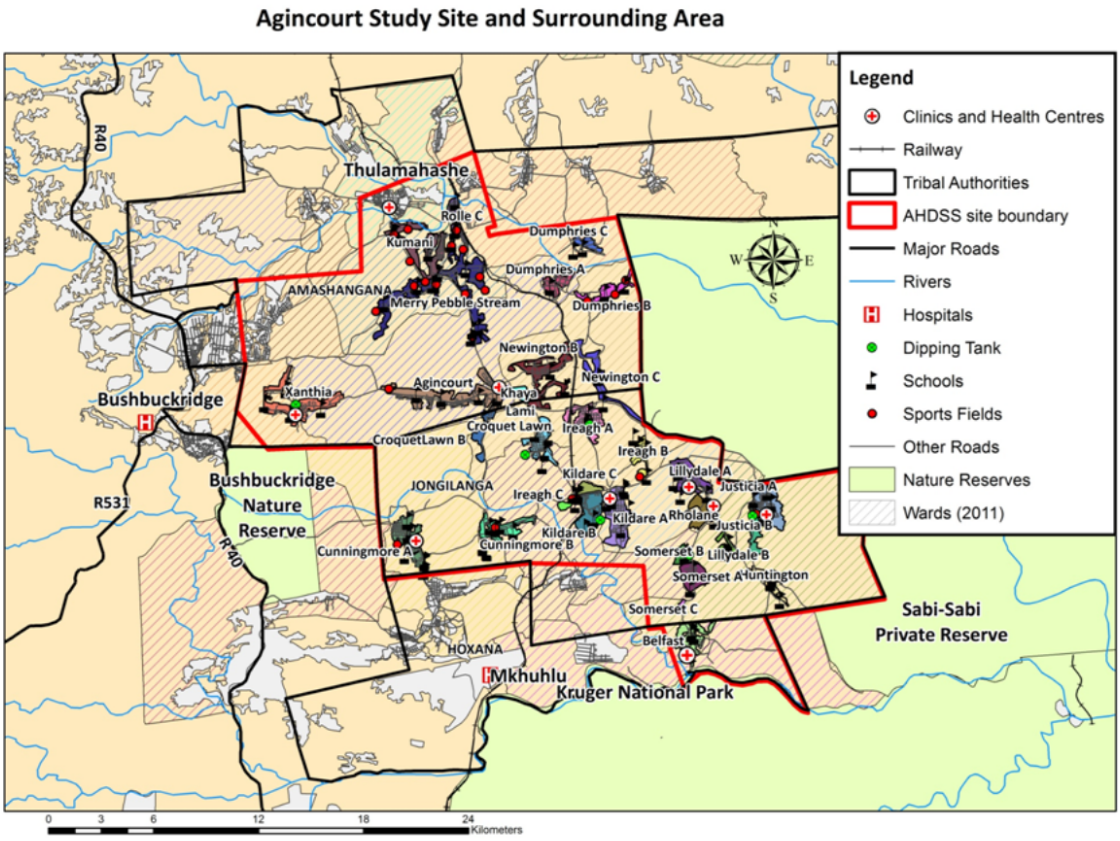
7.4 Agincourt fostering a formative rural knowledge economy

This section presents a narrative of the Agincourt research programme and its evolution from small-scale research project to 21st century globally oriented research institute.

7.4.1 Scope of the Agincourt research programme

The Agincourt research community incorporates 27 rural villages and approximately 90,000 people over 420km², larger than the Agincourt village community of approximately 5,000 people (Kahn et al. 2012).

Figure 7.2 Agincourt study site and boundary for HDSS



Source: *Agincourt Health and Population Unit, n.d.*

The Agincourt Health and Demographic Surveillance System (AHDSS) is "a longitudinal population registration system that monitors demographic dynamics in a geographically defined population" (MRC/Wits, n.d.), effectively a health and population census (Wits, 2009b, p.21):

> The AHDSS has evolved into a robust and mature research infrastructure from its inception as a decentralised health systems development project (1993-97), to a university linked health and population research initiative (1998-2002) to a field-based research and training programme that is central to an interdisciplinary university initiative called 'Population, Health and Society' (2003-2007). A staff

> complement of about 50 people … include, leadership and management, senior scientists, fieldworkers, drivers and data capturers…international scientists from universities such as Cambridge, Harvard, and Oxford participate in various capacities in Agincourt HDSS studies.

In 2008, the Wits Reproductive Health and HIV Research Unit, which had sites in Johannesburg and KwaZulu-Natal, established a research site at Agincourt in collaboration with the Agincourt Unit. The aim of this work was to reduce the rate of new HIV infections in school-going girls, adding to the multiple layers of "intervention research" (Wits, 2009a) conducted at Agincourt. Thus multi-disciplinary collaboration was established (*coded as values: multi-disciplinarity*), and longitudinal research and community engagement became intertwined (*coded as research actor-community value*).

The annual census conducted in the villages of Bushbuckridge revealed that the population is experiencing an epidemiological and health transition (increasing longevity due to greater social investment, but greater presence of communicable and non-communicable diseases). Furthermore, HIV has broken the transition to longevity through high mortality rates. Changes of lifestyle have resulted in high presence of non-communicable diseases at an early age, including obesity and diabetes in young women and cardio-metabolic diseases arising from ART rollout. Communities have been losing one small advantage of living in rural areas by eating foods with a high salt and sugar content and eating less raw and whole foods (key informant AHPU-S3, 2014). The challenge of promoting healthy lifestyles is complex, given the relative scarcity of healthy foods and the relative preponderance of unhealthy foods in nearby towns (many fast food outlets, low cost of carbohydrates versus high cost of proteins) (observation incident 16, Agincourt and Acornhoek, 2014).

7.4.2 An outside-in perspective: what the outsider observes

According to the research service provider for the WRF business case conducted in 2009 (key informant WRF-RFSP, 2014), who spent many hours interviewing research actors and observing the programme, the work of the Agincourt Unit is a "life and death situation", dealing with HIV/AIDS and other health issues in the context of high levels of social and economic deprivation. For international scientists, this was "a wonderful data site, because they could parachute in and out", but this also raised ethical issues of academic value versus community value, notably the risk of the community experiencing limited direct benefit from the research, while the academics furthered their careers and knowledge (*coded as value derived versus value deferred*).

A review of the website shows that the international research collaborations gave rise to over 100 peer reviewed publications (Agincourt Health and Population Unit, n.d.). A review of Wits annual research report for 2008 and confirmed during the study visit shows that the longitudinal research is incorporated into extensive community feedback sessions (Wits, 2009a, p.69) and all key informants reflected that communities benefit from the health and social interventions predicated on the data, as well as from the availability of high quality data to inform local decisions to build schools and crèches, or water and other infrastructure. Hence, both community and academic value can be ascertained (*coded as research actor-community value*).

The key informant (WRF-RFSP) commented on the plans to replicate the health and demographics panel study in KwaZulu-Natal and in particular nodes in East Africa through the Africa network or the INDEPTH network, based on the recognition by the research actors of the need to mobilise knowledge, to organise and share data, and to build institutions (*coded as value: sharing knowledge at continental and international level*).

With respect to the proposed Wits rural sciences institute, the Agincourt group were uncertain how to respond to the interest from Wits senior management and were rather more focused on attracting resources to become more research productive and on the meaning of socially engaged research (key informant WRF-RFSP) (*coded as values: community research orientation*).

7.4.3 Values and value deconstructed

Social engagement or detachment – these are difficult approaches to theorise and to consider which approach is correct. In the Agincourt case, the university did not set out to service the community, but rather to service public policy, which should then service the community on an informed basis. However, it can be argued that public health policy makes limited impact in the far rural parts of South Africa, raising the question how a research unit like Agincourt at a university like Wits would explain or assess the value of rural research. Is academic research valuable because it is available, or does it require university-based mechanisms to promote its utilisation (*coded as value creation*). The Agincourt Unit refers to "intervention research" (Wits, 2009a, p.69), resolving the debate at least in its own view.

One respondent reflected on the future challenges, noting that the values associated with community research were not seen to be as important as the values of academic research, stating that the Agincourt Unit "don't do community based research…the questions are based on researchers interests…should be based on what the results of previous research has shown" (key informant AHPU-S4, 2014). Furthermore, the translation from academic research to policy and health interventions was difficult and the researchers "just never know where our results go" (AHPU-S4, 2014). For example, after 10 years, it was discovered that earlier research on stroke presented to the national Department of Health led to international research funding agency for public health interventions on strokes (*coded as value translation*).

The Agincourt Unit has reflected on the benefit of the knowledge produced by Wits to the broader population in rural villages and towns, the potential for translating 20 years of research into a national asset available to both national and provincial health departments and for public policy. The knowledge hub at the Wits Rural Facility was seen to be an important partner to maximise the value of the research (AHPU-S4, 2014; Wits-RKH, 2014) (*coded as value translation*).

7.4.4 Foundations of a small rural subsistence knowledge economy

Further insight into the Agincourt Unit was needed to understand the process of value creation and the possible emergence of Bushbuckridge as a rural knowledge-based economy. In 2008, the Agincourt Unit had 20 doctoral students engaged in child and adolescent health and development, HIV/AIDS and chronic care (Wits, 2009a, p.69):

> Critical to the research is the corps of multidisciplinary scientists ranging from public health experts to demographers, sociologists, ecologists, anthropologists, geographers and mathematicians amongst others.

The continued research in 2009 involved the "population impact of antiretroviral roll-out", community-based trials for interventions "to promote socio-emotional resilience in 10- to 12-year olds", and interventions to reduce the vulnerability of adolescent girls to HIV (Wits, 2010a, pp.144-145). The health sciences biennial review for 2008-09 reported that all Agincourt research projects are linked to the HDSS research platform and new datasets are continuously being added to the HDSS (FoHS, 2010). In each successive year, the increasing integration of the research with community health and population development issues was observed (*coded as value: deepening knowledge base*). Throughout this period, the project supported Masters, doctoral and post-doctoral research (*coded as value: deepening knowledge base*).

The multi-disciplinary values were apparent from data regarding the multiple intersections and collaborations with researchers at Wits including the Centre for

Health Policy, School of Public Health, Department of Paediatrics and Child Health, Rural AIDS & Development Action Research Programme, School of Accountancy, School of Computational and Applied Mathematics and the School of Social Sciences, to mention a few. Local collaborators included the Africa Centre for Health and Population Studies, Soul City Institute for Health and Development Communication, Medical Research Council, Statistics South Africa and three South African universities. International collaborators included 17 universities in the US, the UK and Europe, and the INDEPTH-Network with the secretariat based in Ghana. These collegial arrangements provided the basis for research intensiveness at the Agincourt HDSS site with respect to rural health transitions (*coded as actor complexity; coded as value: research intensiveness*) that further strengthens the view that a particular form of knowledge economy emergence may be occurring at Agincourt.

In the evolutionary process of the Agincourt Unit, challenges for attention have included shifting from a historical research agenda "to some extent led by funders or collaborators questions, less often led by mining our own results" (AHPU-S4, 2014) to the creation of a research platform where research outputs would be made valuable to rural communities across South Africa (*coded as seeking future value*).

7.4.5 The Agincourt Unit becomes a 21st century institute

In 2011, The Institute for Wellbeing and Development (IWD) was established, later to become one of the 21st century institutes and demonstrated a very highly functional multidisciplinary research platform (Wits, 2012a, p.42):

> The Institute builds on the capabilities and the reputation of Wits in public health, child health and clinical medicine, social and political science including population and migration studies, policy and management sciences, molecular biosciences, computing and statistics, applied mathematics and environmental sciences.

The new institute arose out of the Agincourt rural research platform and urban research platforms such as the Birth To Twenty study referred to in Chapter 5 above (Wits, 2012a, p.43):

> Both of these major community-based research initiatives are entering their third decade and offer strong, internationally recognized platforms from which to engage in critical local, regional and global issues around human development and sustainability.

Given the status of a Wits 21st century institute in 2012, the contestation between academic values and activist values appear to have been laid to rest, even while the values associated with Agincourt and its transition to the IWD were explicitly socio-academic values, rather than narrowly academic values (*coded as socio-academic values*). Perhaps too, the university has shifted in its understanding of values as being narrowly academic and has begun to understand that the confluence of values of academia and society can occur at specific intersections of interests, even where values may lean more strongly towards the academic than the social (*coded as socio-academic values*). Agincourt in the Bushbuckridge local municipality will gain the presence of a 21st century local-global research institute, positioning both community and university more strongly as participants in a formative rural knowledge economy (Wits, n.d.c, pp.30-31).

7.4.6 Strengths and weaknesses of the formative knowledge economy perspective

Considering Bushbuckridge as a formative rural knowledge economy, it was noted that particular features of a formative knowledge economy were present (observation incident 16, 2014), while many specific differences with generally recognised industrial or services-based knowledge economies could be highlighted. Some of the features included:

(i) presence of research-based institutions engaged in long-term research with accessible research infrastructure and funding for community and research actors (includes Wits, University of Pretoria, University of Stellenbosch and SANParks Scientific Services, SANParks Phalaborwa Research Node, and the

national research facility the South African Environmental Observation Network [SAEON]) (Bunn, 2013);

(ii) availability of human capital with a long-term local engagement (academic staff, doctoral students and international scientists engaged in long-term research, collaborating with local and international networks);

(iii) access to international bandwidth (Agincourt Unit is currently using a privately-provided radio-link making available 1Mbps connectivity to Agincourt – the plan is to upgrade to a 300Mbps radio-link to Wits Rural and 50Mbps to Agincourt connecting from the SANReN PoP in Nelspruit, key informant Wits-CNS, 2014);

(iv) one of the missing links is a supportive policy environment and the absorptive capacity on the knowledge demand side;

(v) another weakness is the very early level of integration and usage of research amongst the many stakeholder groupings, some more powerful than others (Bunn, 2013).

When theorising the formation of knowledge economies in the 21st century, it is important to understand that, analytically, we may apply the relevant concepts to any form of economy, even to a small, rural marginalised economy based on subsistence and state grants. In this particular geographic area, the community of Bushbuckridge includes some of the richest environmental resources and capital-intensive game parks and game farms in South Africa through the Kruger to Canyons (K2C) corridor (Bunn, 2013). Reconceptualising Bushbuckridge and surrounding Ehlanzeni and Mopani district municipalities as a highly unequal, but capital intensive and environmentally rich economic sub-region gives possibly greater credence to the attempt to formulate a view on small, rural, less-favoured, formative knowledge economies.

7.5 Multiple knowledge futures for rural health and population research

A few additional features are presented, focusing on the knowledge potential of this particular case and how future value may be derived.

7.5.1 Practicing open science

An important value that the Agincourt Unit subscribed to has been the value of openness, as practiced in their open science approach. There were two dimensions to this openness (i) making available data for research to academics and scientists across the world and (ii) use of open access publishing to disseminate knowledge. The value of providing open access to data (based on formalised requests) has been that scientists engaged in similar research in other parts of the world can acquire and use specific data selections to better understand particular aspects of rural epidemiology in transition (*coded as values: open access to knowledge; coded as value: deepening the knowledge base*) (Kahn et al. 2012, p.999):

> Fostering effective collaborations, ensuring cross-site compatibility of common variables and optimizing public access to HDSS data are priorities. The Agincourt data website… contains full documentation, including questionnaires, data dictionaries and metadata associated with the Agincourt HDSS, as well as an anonymized 10% sample that retains the relational, temporal and data integrity of the full database. Researchers may request a customized data extraction...The questionnaires, metadata and '1-in-10' sample database help users to prepare the detailed data re- quest needed for a customized extraction. The MRC/Wits-Agincourt Unit participates in data sharing initiatives that yield datasets that can be freely downloaded. The INDEPTH-WHO SAGE study (Study on global AGEing and adult health) is available on the Global Health Action and INDEPTH websites…

The value of open access to scholarly publications is that the material is immediately available free to download from the Internet in line with the Budapest Open Access Initiative 2002, enabling access to knowledge for future scientific research (Soros Foundation, 2001):

> By 'open access' to this literature, we mean its free availability on the public Internet, permitting any users to read, download, copy, distribute, print, search, or link to full texts of these articles, crawl them for indexing, pass them as data to

> software, or use them for any other lawful purpose, without financial, legal or technical barriers other than those inseparable from gaining access to the Internet itself. The only constraint on reproduction and distribution should be to give authors control over the integrity of their work and the right to be properly acknowledged and cited.

Other forms of value that arise are making knowledge available as a public good rather than as a private good (Gray, 2010, p.8):

> The collaborative and open research approaches and the wider range of outputs emerging in a changing research environment offer potential for development impact that cannot be achieved through the restricted scholar-to-scholar communication offered by journal articles.

The values of open access publishing were evident from a review of the Agincourt Unit website, which offered free access to 27 articles in the *Scandinavian Journal of Public Health*, Volume 35, Supplement 69, 2007 (impact factor 1.966), all available for download at approximately 1Mbps bandwidth (*coded as values: open access to knowledge*). This has made available a rich source of knowledge for researchers, for health practitioners and for government policy-makers (*coded as value: deepening the knowledge base*). Many other scholarly publications are listed on the website, though these are not available for download (*coded as social value deferred*).

7.5.2 Agincourt e-services and data science

In 2008-2009, several hundred patient records were linked through fingerprints to electronic records made available for (i) maintaining an electronic patient record system for ease of follow-up and maintaining the integrity of the data and (ii) analysis of big data sets to provide greater insight into the meaning of very large volumes of data, as envisaged in the data science initiative proposed by the JCSE. The JCSE proposal with respect to the Institute for Wellbeing and Development big data analytics programme set out the following requirements (*coded as research actor engagement*; *coded as values: multi-disciplinarity*), see Table 7.2 below:

Table 7.2 Extract from formative proposal for data science

Data collection and storage	Data processing and analysis	Outputs, presentation and usage	ICT research and innovation opportunities	Skills development opportunities
Health and socio-demographic data collected in well-established research studies in Soweto (Birth To Twenty+) and in Agincourt… Data sources are at multiple levels: from molecular/ cellular investigation to clinical and individual assessment to household and community levels.	Data cleaning…data exploration, reshaping, extraction for analytical work; statistical analysis; anonymization; encryption; data preparation for public dissemination; GIS (map making and maintenance); data use for management purposes…hand-held device data entry…	Making available public access to datasets of high health and development interest. Publicly accessible data; processed reports; results of statistical analysis; articles in scientific journals; articles in newspapers and other lay outlets; audio-visual materials.	Infrastructure development (e.g. bandwidth improvement…) for the Agincourt HDSS platform … includes … data harmonization and distribution (cloud computing)…large potential of mobile technology as data collection/research tool in rural settings…analytics for very large longitudinal databases, advanced epidemiological modelling…and linkages with high performance computing…	A regional MSc in research-oriented data management has been established, responding to a critical bottleneck limiting the productivity of population-based research. From 2014…Masters degree in research database management…(all aspects of the research database management process from study concept through to data distribution)…

Source: *JCSE, n.d.b*

Discussions with the Agincourt Unit researchers confirmed that big data analytics was a sought after capacity, as the unit did not have the capacity to conduct very large scale data analysis, for example analysis of food security trends, while simplifying data was also important for research-based advocacy on health and social grant issues. Big data analytics can support the process of making the quantitative data meaningful and making explicit the analytical linkages to the qualitative questions relating to the social aspects of health (*coded as value: opportunities for social innovation*).

7.5.3 National research financing

The transition from research unit to a major global research institute was located in an emerging values system that has fostered a sophisticated approach to the

blending of knowledge production for academic research and public use. The long-term sustainability of the programme presented a major challenge, as the challenge has grown commensurate with the size of the programme. In this sense, the successful growth of the size of the programme was also its biggest risk. Funders in 2014 were mainly global funders and foundations located in the USA, the UK, Canada and Switzerland; with important but few South African funders including Wits, the National Research Foundation, the Medical Research Council, Limpopo Department of Health and the Anglo American Chairman's Fund (*coded as resource risk*).

7.6 Wits experimental knowledge hub at Acornhoek, Bushbuckridge, Limpopo-Mpumalanga border area

As earlier stated, the Agincourt Unit is loosely located within the broader institutional frame of the School of Public Health and the Wits Rural Facility. In 2013, based on the resource injection of ZAR13million from the Department of Science and Technology for infrastructure upgrading and research, as well as continued research funding, Wits commenced the process of rethinking the objectives and positioning of the WRF.

The vision document for the Wits Knowledge Hub for Rural Development (Bunn, 2013) highlighted a number of issues of complexity and participation in quantum research games: naïve empiricism in a context of competing political narratives on the strengths and weaknesses of development; comparative absorptive capacity of stakeholder groups with respect to knowledge utilisation and research participation; scepticism of particular stakeholder groups with respect to the value of academic research to government objectives for rural development; engagement with other research actors in the sub-region including other research active/intensive universities and scientific research facilities (*coded as research-actor: research institution complexity*).

In remarking on its commitment to foster its institutional knowledge production and participate in the quantum games of stakeholder research and policy engagement in the sub-region, against identified forms of adversity, the vision document stated (Bunn, 2013, p.20):

> Wits also recognizes its role as a key agent of change, by providing knowledge resources and capacity building for policy managers. Moreover, as an institution located in one of the largest urban areas of South Africa, we recognize the need to train our students and staff in the complexity of rural-urban connections, and to have a vision and a commitment to understanding how every aspect of South African society is linked to, and defined by reference to rural areas. We will not limit ourselves to Bushbuckridge or the greater K2C areas. Rather, our goal must be to constantly research connections between aspects of rural development, and urbanization in rural areas, in southern Africa, Africa, and the world.

A brief overview of the types of research and stakeholder engagement are presented in Box 7.1 below:

Box 7.1 Wits Rural Facility knowledge hub – a rural research campus

The business case for the rural observatory was finalized in 2009 and government was approached to co-fund the academic venture. In 2011, the Department of Science and Technology and the Department of Higher Education and Training approved ZAR13million in funding for the expansion of WRF, including new facilities such as an auditorium and seminar rooms, wet and dry labs, and contribution to the creation of the knowledge hub for rural development.

WRF is situated at the edge of Limpopo and Mpumalanga provinces, 30 kilometers from the Orpen Gate of the Kruger National Park and surrounded by vast tracts of natural reserve including the Timbavati and Klaserie national reserves. The WRF appears to thrive on the complexity of its many associations, including community development fora, traditional leaders, women's groups, and the local municipality of Bushbuckridge. Bushbuckridge is an environmental war zone heavily affected by endangerment of species including rhino poaching, and other forms of environmental degradation. The area faces issues of "staggering difficulty" with the differing management structures of large, and communal, and private game reserves undermining beneficiation projects in national parks. The local municipality is in receivership due to bankruptcy. There are competing forms of environmental and other legislation that the WRF must be knowledgeable about in order to operate in a sustainable way. It is clearly very hard to mediate this complexity and produce knowledge flows and knowledge exchange that can reach all stakeholders on a continuous basis, yet this is the task WRF has set itself, described as a "web of connections and exchanges that are 'beautifully catastrophic' have co-implicated us in everybody's business in this region".

In 2014, the rural knowledge hub is engaged in 10 research projects, including the Agincourt health and population research. Another project is the community-oriented research and knowledge facilitation for the Kukula traditional medical practitioners group. The group has 600 members, who are running out of medicinal resources (plants and herbs) for traditional healing, due to overexploitation of the available resources by commercial harvesters from the cities taking up the resources. Kukula and other traditional healing groups want access to medicinal resources in protected areas like private game reserves for the purposes of benefit sharing. This appears to be an "impossible problem" for research. Through a series of workshops, the various stakeholders including the university, private reserve owners and healers are learning what resources are needed, what plants could be substitutes, contemplating the possibility of growing some resources in nurseries, bringing in researchers to review alternatives, and facilitating knowledge exchange among these groups. Three workshops led to an initial resolution of the problem, with a pilot project starting up in Mariepskop, where a single nature reserve has agreed to grant traditional healers access. Wits researchers will contribute by drafting the protocols for sustainable collecting, in consultation with the interest groups. The research contribution lies in the facilitation of diverse interests and in the knowledge related to promoting access to scarce medicinal plants and herbs. Reference is also made to "strategic adaptive management" from an environmental perspective, with respect to water catchment management.

Considering the values system affecting WRF and the relationship between values and value, for most of its history and today, the university sees WRF as a facility, which is required to produce revenue rather than globally competitive research. "The fact that it is one of the leading savannah and public health research bases in the world, possibly the top one in Africa, failed to get through to people". This is changing, but the old values still dominate. The transformation to a Wits rural research campus is under way, under conditions where the applicable values system is being rewritten. Bushbuckridge has a "huge reputation as one of the poorest spaces in South Africa, but is a research resource of huge proportions and is getting more international attention than before". There is a change in approach, but there is still lack of clarity on the research value of the WRF, now and in the future. Ideally, more resident academics should be teaching from WRF, but it is very difficult to get people to come here, "the distance from Joburg to WRF is greater than the distance from WRF to Joburg".

7.6 Insights for theory building from Agincourt Health and Population Unit (research actors, institutions, resources, values and value)

The research actors pursued their endeavours through highly adverse conditions of limited resources in the rural environment, apparent opposing interests of key actors namely university management and locally based research actors. Though the interests were not initially aligned, pushing through a variety of forms of adversity led to a powerful state of research intensiveness in the long run – 22 years (research commences in 1992, 21st century research institute [IWD] is established in 2013 and WRF knowledge hub transformation commences 2013). The intersection with a very large number of institutions from own university, local collaborators and international collaborators enabled a strengthening of knowledge capacities that infused the capacity to conduct research, to publish and disseminate research that would not be possible with only a few collaborators. The successful state of collaboration 22 years from the commencement of the programme belies the complexity of reaching this state. Furthermore, major challenges lie ahead in relation to creating long-term impact on public policy and service delivery in rural health districts and impact on environmental sustainability. This insight can be generalised to other areas of public policy and delivery of social services.

Knowledge and funding resources are generally the greatest challenge and the greatest risk to the sustainability of research. Lack of access to either one of these resources could lead to the collapse of the programme. On the other hand, keeping the human and finance pipelines open requires an immense investment of time and effort, side by side with the time and effort required to do the research. This involves quantum games and multiple trade-offs between research, publishing, teaching, supervision and fund-raising. The Agincourt Unit case study demonstrates that it is possible to play these quantum games and to win at quantum games. Indeed, the converse of this argument is that success is

unlikely in circumstances where the research actors are not willing to participate in quantum research games.

This case demonstrated the strong relationship between values (the importance of the socialisation of knowledge and boundary crossing, forcing connectedness with new values such as openness and disconnectedness with archaic or narrow interpretations of academic excellence) and value (social value gained, global value gained, academic value gained) as highlighted by Abrahams and FitzGerald (2012):

> …the values held by the pioneering academics namely of putting knowledge in the service of social development, have led to value for the university in terms of the volume and quality of scholarly publishing, as well as availability of indigenous knowledge to the local community. These were not the core values of the institution, nevertheless they were 'good values' which over time have translated into value, precisely because researchers were working at the boundaries of their disciplines.

Values (research-oriented values or values systems) and value (academic, social or economic value) are clarified in this chapter to be important categories for theory building.

Chapter 8 Case studies D and E: Evolution of policy positions on intellectual property rights and knowledge utilisation: Technology transfer and open access publishing

The fourth and fifth case studies are policy practice case studies. They consider the institutional co-existence of and contestation between two paradigms of knowledge ownership in the university context, namely the paradigm of intellectual property rights management and the paradigm of open access to knowledge. The theme of intellectual property rights (IPR) management emerged from the overview of the Wits research sub-system, as the existence of a supporting infrastructure for patenting and technology transfer provides a particular set of research mechanisms only present in universities engaged in the pre-competitive or competitive phases of innovation production. The Wits Technology Transfer Office (Wits TTO) offers this supporting infrastructure. The theme of open access publishing emerged from the university research sub-system overview and from two case studies, namely the 21st century institute case study and the IPR management case study. The Wits Library is an important actor advocating for open access publishing.

A historical view of each of the themes was constructed, based on document review and interviews, to create the case study. These subjects are of university-wide strategic interest, have implications for the broader higher education system, have high levels of complexity and have been the subject of contestation between their advocates and their detractors.

Open access scholarly publishing is a social movement across universities in many types of formative knowledge economies (Suber, n.d.). In the early stages of the grounded theory investigation in 2008, it appeared as though ICT infrastructure could be an interesting line of enquiry. However, open access publishing on the Internet arose several times during the course of the enquiry,

raising issues of research accessibility and visibility, thus leveraging the available infrastructure to provide a more direct form of value than the indirect value created by the infrastructure itself. This drew attention to the dimension of digital transformation in universities, with open access publishing being one arena of such digital transformation. As Hanna and Summer (2015, p. 62) state, ICT brings a "deep socio-technical transformation" rather than introducing a "short-term technological enhancement". It can further be argued that digital transformation includes socio-technical (where institutions and society are connected with technological change), socio-strategic (where institutions and society must continually adjust their strategic approaches as technologies advance) and techno-economic dimensions (where technology and economic change are interconnected).

These are rather different stories of complexity, uncertainty and contestation. The contestation relates to the understanding that actors have of the value of patenting and the value of publishing, as these have in the past been posed as alternative choices, rather than as connected activities (participant observer incident 4, 2008). At a few universities in South Africa (UCT, University of Pretoria, University of Stellenbosch, Wits), research has matured to the stage where inventors are now engaged in early stage innovation, in particular in pre-competitive research leading to novel discoveries, for which they then seek patents through local and international patent offices. This follows a global trend at research-intensive universities, but little is known about this field of practice in South Africa.

8.1 Case study D: Evolution of IP management at Wits 2003-2014

A significant amount of data was collected during the course of the grounded theory study, of which only a portion is documented here, with particular focus on the IP management perspective, rather than on the inventor perspective. A more detailed account of the relationship between IP management and open

access publishing is documented in two co-authored papers (Ncube, Abrahams & Akinsanmi, 2012; Ncube, Abrahams & Akinsanmi, 2013).

Formalised, structured management of intellectual property for R&D and innovation, and strategy and tactics for supporting open access publishing have emerged as research approaches in South African universities only in the 21st century.

8.1.1 Legislative environment and IPR management in universities

The Intellectual Property Rights for Publicly Funded Research Act, No. 51 (IPR-PFRD Act) was passed in 2008 and came into effect in 2010. Prior to 2008, universities had initiated policies on the ownership of intellectual property arising from research conducted at the university, with the Wits "Research Policy on Ownership of Intellectual Property" approved in 2003. The introduction of legislation for IPR management led to the revised Wits Intellectual Property Policy adopted in 2012 (Wits, 2012e). The rationale for intellectual property rights law specific to universities and publicly funded research institutions was "…to provide for more effective utilization of intellectual property emanating from publicly financed research and development…" (Republic of South Africa [RSA], 2008, p.2). The Act includes in the definition of intellectual property that which is patentable and excludes copyrighted works and "any other publication… associated with conventional academic work" (RSA, 2008, clause 1(c)).

The IPR-PFRD Act aimed to encourage the patenting of novel ideas and their commercialisation, in order to drive value from the several billion rand of public funding that enters the higher education and science council system each year (DST, 2013), though only a relatively small proportion of this funding is likely to lead to novel discoveries. The Act requires universities to promote inventions, patenting and technology transfer; and therefore requires the establishment of significant institutional infrastructure on the state side and on the university side,

in order to translate knowledge into prototypes, or licenses for new technologies, as steps towards commercialisation. The legislation and the associated regulations specifically require the establishment of university technology transfer offices to manage the IP commercialisation process (RSA, 2008, section 6).

The technology transfer office at Wits (Wits TTO) resides in Wits Commercial Enterprise (WCE), a wholly owned company of the university. Wits TTO is responsible for filing patent applications and facilitating commercialisation through licensing IP and other means. Its knowledge capacities pertain to the complexities of generating IP and facilitating commercial advantage, patenting, scholarly publishing and other forms of dissemination of knowledge arising from scientific inventions (key informant Wits-ERM1, 2012; small group discussion Wits-ERM, 2014). By 2010, only a small proportion of Wits approximately 2,500 academics were actively engaged in patenting, in a few programmes, in the health sciences, in the natural sciences and in engineering (Wits-ERM1, 2012). The university is at the early stages of understanding the nature of the R&D and innovation landscape and has not yet formulated a strategy to foster active innovation and patenting.

The conversation about fostering commercialisation of publicly funded research has been an embryonic conversation involving universities, NIPMO, TIA, the DST, industry and many other parties. One of the benefits of a growing patent portfolio was seen to be encouraging partnerships with TIA and the private sector. Thus, despite early concerns about possible negative impacts of the legislation on IP creation, at least a few of these concerns have been smoothed out as the broader legislative and regulatory context began to mature. It was argued that (group interview Wits-ERM, 2014):

> …makes a big difference if you've got that part well established…because statutory IP protects the potential partner's interests as this is a means to holding

off competition from other potential investors until they can recoup their investment.

8.1.2 Investment in fostering patent applications

Wits became engaged in patent activity in circa 2003, though it filed few patent applications in the period to 2007. Before the IPR Act it could be said to have been generating a patent archive and a few contracts, but had limited engagement in technology transfer. By 2013, Wits was funding the filing of patent applications to the value of ZAR4,5 million per annum (mainly the fees for patent attorneys) and ZAR2,5 million per annum for facilitation of technology transfer (mainly staff salaries), for a total annual investment of approximately ZAR10 million including services, land and buildings, or less than 1% of total annual research contract income (*coded as applied resources*) (Wits-ERM small group interview, 2014), see Table 8.1 below. The data shows that research income has increased steadily, though a significant proportion of this increase would be due to inflation. The increase in patent activity indicates a particular feature of the transition from research activeness to research intensiveness.

Table 8.1 Wits income from research contracts, grants and donations

2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
ZAR'000	ZAR'000	ZAR'000	ZAR'000	ZAR'000	ZAR'000	ZAR'000	ZAR'000
443 400	494 756	469 226	648 473	717 593	620 042	701 752	820 750

Source: *Wits annual financial statements 2005 to 2012 (Wits annual reports 2006-2012)*

There is limited data available on the invention and patent profile over the last decade, available data is listed in Table 8.2 below.

Table 8.2 Invention and patent profile

Invention disclosures	**Patent applications filed**	**Patents granted**
34 (2013)	77 (2013)	23 (2013)
26 (2012)	50 (2012)	16 (2012)
20 (2011)	74 (2011)	31 (2011)

25 (2010) 16 (2009)	71 (2010) 66 (2009)	15 (2010) 19 (2009)
121 in 5 years	**338 in 5 years**	**104 in 5 years**

Source: *Wits TTO, 2013 and 2014*

8.1.3 Inventors and technology transfer offices

Of the inventors supported by the Wits TTO, the Wits Advanced Drug Delivery Programme (WADDP) in the School of Therapeutic Sciences was selected for study because the scientists held the highest number of patents at Wits in 2012 and the programme expressed some of the intricacies associated with university IP management.

Many technology-based sectors operating in South Africa, such as the pharmaceutical sector, have not been engaged in original innovation development locally, but have large-scale research laboratories in other countries. In these sectors, local inventors seeking to attract a company to license their technology for further development would need to attract global firms to acquire the license (*coded as complexity of global markets for innovation – adds a possible sixth unit of analysis, namely innovation markets*). This has required the inventors to file patent applications in a number of patent domains globally, where the relevant markets were well established. In the case of pharmaceutical inventions in advanced drug delivery, the countries in which the Wits inventors filed patents were the European Union, Japan and the United States, as well as in South Africa (*coded as actor-institution connectedness*) (key informant Wits-RI, 2012).

In the patent application process, the inventors filed provisional patents with the South African CIPRO[21] in order to receive a priority date. After extensive further research to test and confirm data, PCT applications were made in the United States, European Union, United Kingdom and Japan where desirable. Publication

[21] CIPRO is the Companies and Intellectual Property Rights Office

of the research could proceed after receiving the priority date from each particular authority (Wits-RI, 2012). Patent examination is an important process in advancing novel discoveries as the examination process (by patent offices) can provide guidance or advice to inventors and their institutions on clarifying the commercialisation potential of the discovery and on other issues related to the invention. However, the patent examination process in South Africa has been relatively weak, as the patent office, CIPRO, has not had relevant expertise (*coded as directed knowledge of actors/human resource constraints*) (Wits-RI, 2012).

Wits IP policy 2003 created Wits Commercial Enterprise (WCE) to advance the commercial dissemination of knowledge resident in the university and to conduct technology transfer, though funding over most of the period 2003 to 2010 was for registering IP, rather than for technology transfer. Funding for mining the patent portfolio and for initiatives to commercialise a careful selection of registered IP only commenced in 2012 with the employment of dedicated and experienced staff to fulfil this function (email correspondence with Wits-ERM2 key informant, 2013). Funding for commercial ventures was made available because of the growth in the patent portfolio to more than 100 technologies/ discoveries, recorded in a few hundred patents in several patent families (*coded as new resource initiatives*). The establishment of the technology transfer office (TTO) in 2012 could have transformed the capacity of Wits to successfully commercialise a few inventions, but the challenges of such commercialisation were highly complex, including prioritising "those patents, trade marks and designs where there is realistic prospect to commercialise them" (email correspondence with Wits-ERM2, 2013) (*coded as values: prioritisation*). Approximately one third of the discoveries were prioritised for commercialisation ventures in 2013, requiring extensive market research and networking with industry, key players in the broader ecosystem.

Support for commercialisation from amongst the researcher pool has varied, but more academics have become interested in advancing from publishing articles and papers to patenting and commercial impact (Wits-ERM1, 2012). Amongst the leaders in patenting, scientists in the Department of Pharmacy and Pharmacology in the School of Therapeutic Studies had filed 38 patents in South Africa and abroad between 2005 and 2014, noting that some patents may have been combined or allowed to lapse. The inventors assigned the IP ownership for the largest single patent family to the University of the Witwatersrand. The research involved the prototyping of a novel drug delivery platform, potentially providing greater value at lower cost as compared to the development of new drug molecules (FoHS, 2012, p.35; Wits, 2010, pp. 103-105). The inventors have been engaged in multiple international research collaborations, regularly establishing new collaboration and co-publishing approximately 15 journal articles annually (FoHS, 2012, p.35):

> A drug delivery patch which combines novel, patented electro-conductive hydrogel technology developed by the WADDP is envisaged, the concept being that the electro-conductive hydrogel will allow controlled release of drugs by electrical stimulation…

8.1.4 Complexity of managing technology transfer and shift in capability

In a 2012 discussion, Wits Enterprise noted that all researchers who utilise public funds would need to become conversant with applicable aspects of the IP legislation, regulations and guidelines, in order that they may recognise whether they have IP they need to disclose (*coded as knowledge of actors*). The researcher would nee to know when to disclose to the university, based on the prior art and the state of knowledge in the relevant field. The IPR-PFRD Act provided that, in the first instance, the university would own the IP (there are other modalities of ownership) and the inventor would share in the financial and non-financial benefits, including approximately 20% of gross revenues (key informant, 2012). Thus, one of the key challenges for the TTO has been to assist researchers to

become more knowledgeable of the terms of the legislation as it affects the inventor, as it affects the university and as it pertains to the public good.

After the introduction of the IPR-PFRD Act and shifts in leadership, new ideas emerged leading to "70% of a full-blown tech transfer capability" (small group discussion Wits-ERM, 2014), but the TTO still faced lack of incubation capability and limited capacity to secure funding for pre-competitive R&D. Other challenges included the lack of capability to determine whether Wits owned patents were being infringed.

The IPR Act required universities to calculate the full cost of research in order to determine which research falls within the ambit of the Act or outside the Act. This knowledge has given the TTOs a more accurate idea of the real cost of research, focusing the attention of scientists on how to price research, rather than charging a minimal fee to an industry partner. Many researchers have not been keen to charge full cost, but are learning that their programmes are effectively footing the bill for early stage research conducted for firms who would then own all the IP. Moreover, charging industry players less than full cost for the initial R&D would undermine the university's capacity to develop the IP through the pre-competitive stages of commercialisation that could conceivably occur within the institution (*coded as knowledge of actors*) (group interview Wits-ERM, 2014).

As indicated above, a major part of the complex arrangements and capacity requirements of the TTO related to framing the practitioner environment for research actors. The experience of the TTO in the period 2012 to 2014 revealed that the focus was as much on shifting the individual researcher's perspective from publishing in Nature and Science to seeing a product or service become a success, as it was on filing patent applications or building market interest in funding the next stage of pre-competitive R&D.

Also required was extensive knowledge building on the relationship between patenting and publishing. Patenting, which is a form of publication, must start before publishing, requiring at most a few weeks delay in publication if any. However, due to the continued emphasis on publishing scholarly papers, there has been a strong tendency for researchers to publish before disclosure of their inventions, even though the publication process is generally sufficiently lengthy to enable researchers to file a patent application when submitting the article for peer review. Putting publication before patenting means that the TTO often has "to scramble to file a provisional patent in the grace period…(if) they destroyed the novelty…cant get the statutory protection we would have liked" (group interview Wits-ERM, 2014).

The key informants reflected on the "need to get the game to the stage where scientists are asking the TTO to check the potential for patenting" (group interview Wits-ERM, 2014) before submitting a conference paper for publication and at an early stage of the review process for journal articles. Mis-explanations were present in the university with some scientists holding the view that it is not possible to publish if you patent. To address these weaknesses, the idea was formulated to appoint IP scouts in the key faculties where patenting is likely to occur, with funding from the governmental National IP Management Office (NIPMO), as a way to get intelligence into the system.

By 2014, Wits inventors had produced novel discoveries of approximately 120 individual technologies, most of which have some form of statutory protection, of which about one third have been prioritised for licensing and possible spin-outs. The TTO has recommended to the IP Committee that Wits abandon about 40 patents in the current portfolio from 160 to 120, noting that there are new disclosures on a regular basis. Increased capability in the TTO has meant that Wits has become more proactive and robust about making decisions on its patent portfolio. Specific tasks included doing background checks on novelty, filing the

patent application, getting feedback from the examining process on combining individual patents to get a stronger patent, conducting market analysis between the provisional patent application and the final application, all making for a highly complex and constantly moving environment nurturing relationships among multiple university research actors, local and international patent offices and industry actors (*coded as innovation complexity*).

8.1.5 Fostering innovation through team values not compliance

The interview discussion of team values examined the psyche of complexity, and refers to the technology transfer facilitation process as a "contact sport", based on a style of working with researchers one-on-one, where a TTO manager may (group interview WCE, February 2014):

> sit with a researcher for hours answering all questions, discussing and checking that all parties have the same understanding…building trust, adding value, not in compliance mode, "you must talk to us because of legislation"…put in the time, support don't dictate, engage in constant re-explanations of incubation and spin out (advantages), understanding those different stages, patience, building relationships, hard to know when to let go, how to let go, try to facilitate, tell the academic when to step back…and when to engage… difficult to tell the academic they wont be the CEO of the company… Face to face discussion and Skype calls are very important, and while this takes up a lot of time, it is believed that it will build the right research culture.

Building the values system for IP management and technology transfer has meant building relationships with important stakeholders in the Research Office, providing guidance on the value of the patent portfolio. One particular benefit would be that the effective management of the portfolio encourages flows of research funding to Wits due to the increasing research intensiveness and quality of research capacity demonstrated by the portfolio. Multiple relationships have to be managed simultaneously noting the interests and risk profiles of different players, for example researcher-inventor or research office or industry financier, and the values associated with this particular form of innovation, such as risk and reward, need to be formulated and conveyed to the players (*coded as innovation resource capacity building*).

Ethical and competitive considerations are more complex issues in the value system, since private investors would seek to profit from their investment. Furthermore, patents have a limited lifespan so inventors have to keep innovating faster than their competitors. The university would need to better understand the pre-competitive and competitive process and adopt a clearer associated value system pertinent to R&D and commercialisation (*coded as challenge to traditional university value*s; *coded as reinterpretation of traditional university values*).

8.1.6 Resource inputs and the challenge for value creation

The new demands emerging from inventors around 2010, to move beyond patenting, required Wits to shift from funding patenting to funding the transfer of patents into outcomes (*coded as commercial value*). To maximise the value of its scarce resources invested in any area of technology transfer, the university would need to base patenting decisions on high quality background information and market research in the field of the patent, in order to patent only where this would create value, as patenting comes with a very large overhead and expense (key informant Wits-RI, 2012). For example, public funding for advanced drug delivery from the DST, NRF and TIA made a contribution to identifying the novel discovery and to early stage technology transfer, but the ensuing phases of commercialisation could cost ZAR200 million or more, and thus international funding and expertise would be needed (*coded as resource availability*).

For the period from 2007 to 2014, Wits funded the patenting and registration of IP, with no financial limitation set, to the tune of ZAR 4 to 5 million a year to cover the costs of patent attorneys and related services. It put approximately ZAR2.5 million per annum into the work of the TTO, mainly used for staffing, expenses and for managing patents, rather than for direct investments in the

science or industry related aspects of technology transfer. The work of the TTO is (group interview Wits-ERM, 2014):

> …to sit with researchers and create clarity between inventor and patent attorney, facilitation of how to do novelty searches and other capabilities that the legal office doesn't have.

According to the key informants, the levels of awareness among researchers, inventors and university management (*coded as actor awareness*) of the value the TTO can add have been sub-optimal (*coded as potential value*), and it remains a challenge to make that value known due to resource constraints (*coded as resource availability*). Available innovation funding was spent largely on innovation facilitation, in particular on mentoring and coaching inventors and patent holders with respect to their rights and with respect to the steps that need to be undertaken to move into the technology transfer phase, and on attracting and contracting industry partners for licensing novel discoveries (*coded as resource utilisation*).

The absence of funding to translate patents into innovative products and services has created a funding bottleneck for university-based innovation activities, a bottleneck that the TTO is trying to open by drafting an IP strategy for Wits inventors, including identifying industry partners, establishing programmes for coaching the entrepreneurial researcher, as without those capabilities the chance of successful technology transfer is low. With the objective to increase the volume of transactions linked to funding technology transfer (*coded as resource pipeline*), the TTO team aims to find companies to buy 10 licenses per year, but this is a medium to long-term goal. Research visibility (*coded as values*) arising through patenting and licensing can significantly increase funding flows from industry for university research, particularly in the natural sciences and engineering. "It is more important to get it out there than think we can make a fortune – money in comes as a result of branding", noting specifically that a firm may fund a large research programme at Wits though the linkage may be too tenuous to show a direct correlation between the particular research funding and any specific

licensed technology (*coded as indirect resource benefit*) (group interview Wits-ERM, 2014).

In the experience of the TTO team, Wits has done significant patent filing over a 10-year period, however out of a particularly large patent family not one novel discovery has been licensed (*coded as value postponed*). There have been "various nibbles and companies walk away" (group interview Wits-ERM, 2014), because international firms may be risk averse or because local firms don't want to repeat the necessary clinical trials or because the market for the particular innovation is not highly developed. The TTO experiences major challenges at every point of driving deals for licensing technology proposed by Wits inventors (*coded as actor capacity/actor uncertainty/actor tenacity*).

8.1.7 Overview of innovation resources (funding and staff) at Wits

Innovation at universities is a relatively new phenomena practiced at very few such institutions globally. While a few universities are renowned for their innovation activities, innovation is not yet regarded as one of the university missions, generally agreed to be teaching, research and social engagement. Wits University has played a limited role in providing funding for innovation activities and has not directly funded technology transfer, namely the processes associated with translating a novel discovery into a prototype, or other forms of pre-commercialisation innovation (*coded as resource availability/resource pipeline*). The most important source of funding to fund those components of the innovation process that occur between patenting, licensing, the production and testing of prototypes, manufacture of the "best" prototype, or improvements to the innovative service, is the governmental Technology Innovation Agency (TIA) established by legislation in 2008, as the TIA mandate is "to stimulate and intensify technological innovation" (RSA, 2008b). However, TIA is not currently providing funding, resulting in lack of funding flows to universities (*coded as*

institutional complexity and resource availability/resource pipeline/resource flow management).

There are few alternative sources of funding for university-based inventors to encourage their innovative activities, as the National Research Foundation (NRF) mainly funds basic and theoretical research (NRF, n.d.), while the South African private sector, venture capital and the Industrial Development Corporation (SAVCA, n.d.; IDC, n.d.) have limited or no engagement in funding high risk early stage innovation and spin out companies (*coded as undeveloped resource capability of the innovation system/resource gap*). Wits provides limited funding for applied research, partly because it has a relatively small research budget compared to the putative cost of converting innovation potential already existing in the institution into innovation outputs (*coded as potential value /resource availability*) and partly because there are no generic innovation funding streams to South African university-based inventors other than TIA (*coded as resource pipeline*). Funding has to be identified for each instance of prototype development, or other aspect of technology transfer; companies have to be sought to license a particular technology and to invest on a medium to long term basis in the development stages of getting the product or service ready for market (*coded as resource flow management*) (group interview Wits-ERM, 2014).

Human capital in the university-based innovation sphere was reported as not only a scarce, but also an irreplaceable resource. The key informants advised that facilitating innovation required a particular blend of skills and experience, which was not readily available in South Africa, noting that lawyers are trained to mitigate risk, while technology transfer is about taking risk, underpinned by statutory protection (*coded as directed knowledge of actors/human resource constraints*). Facilitators would need business, commercial and marketing ability and would need to have the tenacity to develop the knowledge and the funding partnerships for two to three years to conclude a potential license deal (*coded as*

time as a resource). Facilitators should have an understanding of science and engineering and empathy for inventors "you can't engage with a physicist about their invention if you have never spent time trying to develop a technology" (*coded as directed knowledge of actors*) (group interview Wits-ERM, 2014). University technology transfer has been slowly gaining momentum and the innovation system has not had the capacity to meet the demand (*coded as scarcity of actors; coded as scarcity of resources*).

8.1.8 Socialisation of university-based research knowledge

In contrast to the commercialisation of research, the socialisation of this same knowledge through publishing and other forms of dissemination (public lectures, scientific conferences, teaching, web-based research papers) is as important as its commercialisation because (i) the public availability of research within the scientific community enables the knowledge to be shared with other academics, scientists and students for the general advance of the scientific knowledge base, while (ii) the wide availability of the published knowledge enables other researchers to build further research beyond the capabilities or resources of the originators.

A number of key informants raised the following discussion: South Africa does not have the resources, institutions or markets to effectively commercialise even a fraction of its IP (various key informants, 2012); (ii) local and global industry has limited awareness of the capability of South African universities with respect to R&D. Given these challenges, the inventor view is that building the knowledge base to advance R&D requires both philosophical and practical interventions, including greater visibility of research through publishing in copyright and open access formats (key informant Wits-RI 2012). A few researcher-inventors at Wits are keen to pursue both commercialisation and socialisation of knowledge as simultaneous ventures, filing patent applications, publishing under copyright licenses and publishing under open access licences, thereby enabling citation of

the work, as complementary forms of commercialisation and socialisation of knowledge (Wits-RI, 2012).

A few inventors published in both copyright and open access modes, because copyright is required for publication in specific journals, while open access increases citations and simplifies access for academics across the world and for those who cannot afford access to copyright publications (Pillay, 2013). Some inventors did not share the data related to those patents that have commercial potential, but were keen to share other knowledge obtained in OA publications. The objective was to create attention for the inventors, the institution and the country. To this end, OA has given greater advantage than copyright approaches, but a barrier to OA publishing has been that the cost can be restrictive (Wits-RI, 2012). High visibility has led to approaches for research collaboration from researchers in Egypt, Argentina and Mauritius (*coded as values: visibility of knowledge*) (Wits-RI, 2012).

8.1.9 Wits institutional IP policy

The preamble to the 2012 policy document stated (Wits, 2012e, p.2):

> The University believes that it would be beneficial to the University itself, all members of its community and the public good if the University uses its resources in co-operation with its staff and students to enable the intellectual property created by them to be utilised for commercial or social benefit, where this is appropriate. The University recognises that such a process will be successful only if it is inclusive and reciprocal. This policy has been prepared in this spirit and for this intent and to protect the intellectual property rights of the University and all members of its community.

The university policy offered inventors the full income for the first million rand, and 70% of all subsequent income for the same invention. This was a good starting point in making the policy attractive to inventors, but required the university to make a large investment (not provided for either in policy or practice) or find an investor. The policy did not state any of Wits obligations with respect to promoting IP management or technology transfer and

commercialisation or beneficiation for social impact.

The most crucial issue in the policy was clause 5.1 on the development of IP (Wits, 2012e, p.6):

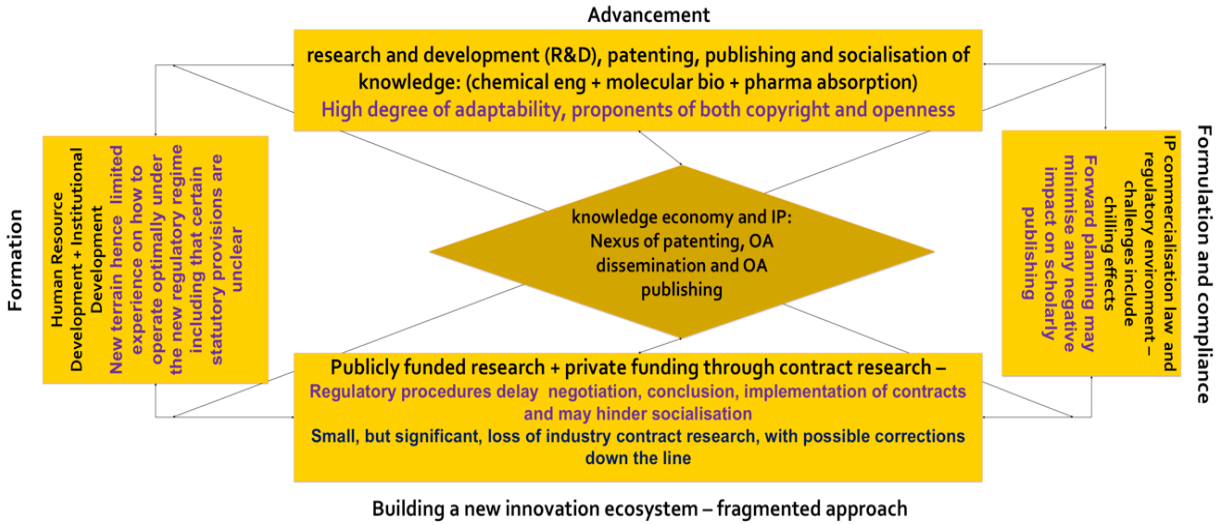
> IP belonging to the University and not in the public domain may only be disclosed with the permission of the Vice-Chancellor, any Deputy Vice-Chancellor, the University's Registrar or the Dean of the Faculty in which the IP arose. Prior to disclosure the IP shall be reviewed to identify any IP protectable through statutory registration. Improper disclosure may adversely affect such registration or the protection of other confidential information.

The interpretation of disclosure was not listed in the definitions clause. Furthermore, capacity for control over disclosure at the levels of management mentioned was highly unlikely as the relevant managers would have to take advice from the TTO. While the intention of the policy was to address the concerns identified by the TTO, the policy set out an apparently more compliance driven statement than the facilitation orientation of the TTO (*coded as compliance-driven institutional policy*).

8.1.10 Summation: The state of university IP management at Wits

Figure 8.2 below, presented at the Open A.I.R. Conference on Innovation and Intellectual Property in Africa in December 2013, set out a perspective on the state of IP management at Wits and UCT. It reflected on the formulation of IP law and the push for compliance with legislation, in the context of a fragmented approach to building the IP component of the innovation ecosystem, the early stage formation of the relevant human resources and institutional environment and the adaptability of the inventors in their attempts to advance the utilisation of their intellectual property. It showed the role of open access publishing to be complementary to, rather than in conflict with the possible commercialisation of IP.

Figure 8.1 The state of IP management 2013



Source: *Ncube, Abrahams & Akinsanmi, 2013*[22]

8.2 Mobilisation of research-based knowledge on the World Wide Web

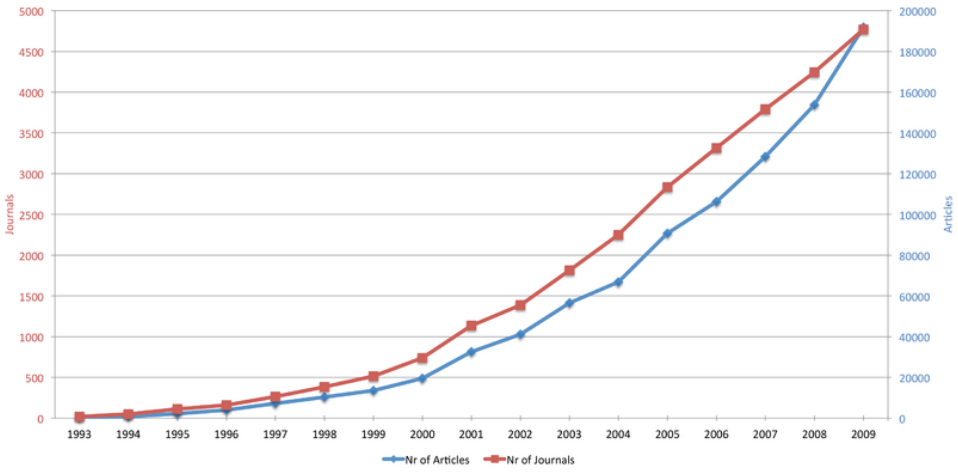
Open access approaches to scholarly publishing have evolved since the 1990s, due to the ease of electronic dissemination and accessibility of the Internet, becoming a popular medium amongst a broader academic community in the decade 2000 to 2010. Suber (n.d.) states that "the open access movement is the worldwide effort to provide free online access to scientific and scholarly research literature, especially peer-reviewed journal articles and their pre-prints". The first online-only open access journals originated in the physics and computer science disciplines through scientists self-archiving the pre-prints of their journal articles (Suber, n.d.). One of the first open access publishing platforms was the Public Library of Science (PLoS).

The following highlights from Suber's (n.d.) timeline are pertinent to the data presentation that follows: Open access approaches pioneered by academics led to the launch of several initiatives to promote open access including the African

[22] Published slide presentation, conceptualized, drawn and elaborated by Abrahams

Journals Online (AJOL) in May 1998 and the launch of the Scholarly Publishing and Academic Resources Coalition (SPARC) by the Association of Research Libraries in June 1998. More importantly, statements and declarations were issued, signed by prominent scholars or committed to by institutions, including the Declaration on Science and the Use of Scientific Knowledge issued by the UNESCO-ICSU World Conference on Science in July 1999; the Budapest Open Access Initiative published by the Open Society Institute in February, 2002; and the Bethesda Statement on Open Access Publishing released in June 2003. These early formulations of an open access "charter" culminated in the Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities October 2003, hosted by the Max Planck Institute. From circa 1987, when almost no journals were freely available online, to the 2012 10th anniversary of the Berlin Declaration, celebrated at a conference at the University of Stellenbosch, a revolution occurred in scientific articles and scientific journals published in open access on the Internet, see Figure 8.2 below.

Figure 8.2: Increase in number of open access articles and journals from 1993 to 2009



Source: *Laakso, Welling, Bukvova, Nyman, Bjork, et al., 2011*

Signing the Berlin Declaration commits signatories to promoting open access at their institutions, whereby authors and rights holders are encouraged to grant

users a right of access to and license to use the work, subject to attribution of authorship. The Declaration highlights the following goals (Max Planck Institute, 2003):

> …the Internet now offers the chance to constitute a global and interactive representation of human knowledge….(enabling signatories) to significantly modify the nature of scientific publishing as well as the existing system of quality assurance….to promote the Internet as a functional instrument for a global scientific knowledge base…. We define open access as a comprehensive source of human knowledge and cultural heritage that has been approved by the scientific community.

8.2.1 South African focus on open access publishing

The Academy of Science of South Africa (ASSAf) is engaged in studying the value of South African scholarly journals. In 2006, ASSAf conducted a review of scholarly publishing. Explaining the terminology and value of open access, the review states (Page-Shipp & Hammes, 2006, p. 89):

> The term Open Access encompasses a specific online publication business model as well as a range of channels for making research literature available to everybody at no cost. It is based on the philosophy that the research literature, which is not written for profit but for the advancement of science and which is largely funded by public money is a public good and should be accessible to everyone who has a need for the information.

The relevant chapter in the ASSAf report discusses the components of e-research [e-science (transfer, sharing, manipulation, modelling and analysis of large datasets); digital curation and preservation of datasets and databases; and access to online content through both commercial and open access publishing]. It argues that the Internet creates a new dynamic of knowledge production and sharing, noting the most salient trends, including (i) challenges to the historical system of peer review as time-consuming, anonymous rather than transparent, and upsetting the global bias of journals towards greater availability of developing country research; (ii) challenges of web-based journal publishing and quality assurance; (iii) publishing and access costs; (iv) the shift to OA journals (v) the value and impact of OA (Page-Shipp & Hammes, 2006, pp. 82-102). The report

illustrates that the case for open access publishing has been presented in South Africa though adoption by universities is limited.

Following publication of the 2006 report, ASSAf promoted open access scholarly publishing by creating specific supporting infrastructure (i) the provision of the Scielo South Africa online platform and accreditation by Scielo (Brazil) and the signing of an agreement with Thomson Reuters Web of Science providing that local journals listed on Scielo South Africa would also be listed on the Web of Science (participant observer Scielo South Africa accreditation, 2013) and (ii) establishment of the Committee on Scholarly Publishing in South Africa, which reviews scholarly journals in broad discipline categories, one of the outcomes being to recommend selected journals for publication on the Scielo South Africa open access platform.

8.3 Case study E: Wits open access journey 2003 to 2013

The case study was prepared using data collection methods of participant observation at Wits Open Access weeks in 2010 and 2011, semi-structured interviews conducted in 2012 and 2014, participant observation at the Wits SPARC seminar on Research Productivity, Open Access and International Visibility held in November 2012, review of the presentations made at the 2013 workshop, document review of annual reports and workshop minutes, review of the Wits research strategy 2012 – 2017, review of selected journal articles published on ResearchGate, website review of the Wits Enterprise website and the Wits Library website, as well as review of email correspondence with some of the key informants.

Academics may choose to publish under an open access license in circumstances including research related to patenting, research related to non-patentable scientific knowledge, and research in the humanities or management sciences where work is typically not protectable. Many challenging issues arise in open

access publishing, including when and how to promote either open access or copyright publication. The case study institution did not have a clear policy direction to academics on its stance on open access publishing, despite having signed the Berlin Declaration.

At faculty level, scientists in physics and computer science were following the global practice in their disciplines of self-archiving the pre-prints of their articles (*coded as values: visibility of knowledge*). This practice was restricted to particular fields. A more focused initiative to promote open access commenced in 2008 with awareness events such as annual Open Access week celebrations, and a presentation to a Wits SPARC workshop in July 2011. These proceedings influenced the Senate decision to sign the Berlin Declaration. Further presentations were made to the Humanities and Science Faculty Research Committees in 2012 and the Health Sciences Faculty Research Committee in 2013. A highlight of this period was the Wits SPARC seminar titled Research Productivity, Open Access and International Visibility, held on 9 November 2012 at which the Vice-Chancellor signed the Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities (participant observation incident 9, 2012).

8.3.1 Promoting open access scholarly publishing at Wits

The history of promoting open access in scholarly publishing has revolved around Wits library services. The drive for open access at Wits started when the Head Librarian introduced electronic theses and dissertations (ETD) in 2003, though this was voluntary at the time. The Senate Library Committee approved compulsory publication of examined theses and dissertations on the library portal in 2006 (key informant Wits-L, 2014).

The Wits electronic library e-journal portal provides campus and remote online access to thousands of electronic journals from many publishing houses, such as

Emerald Publishing, as well as access to many electronic journal databases including the Directory of Open Access Journals (DOAJ) and other open access libraries and repositories. This includes access to journals indexed by Thomson Reuters Web of Science, Scopus and others. Electronic access reduces the cost and inefficiency of procurement to the university and the time to access material for academics and research students, making it possible to increase the productivity of the student body as a whole in producing essays, theses and dissertations, academic journal articles and other scholarly writing (*coded as investment in electronic resources*) (review of Wits Library website, 2013).

Remote access means that Wits students across the continent can access a wide array of journals in their field and on their topic of study, while collecting data in their country of residence. The e-Wits Catalogue makes content searchable, including more than a million digital images from the arts, architecture, museums and photo-archives through ARTstor; global country risk reports and forecasts for 175 countries and 22 industry sectors through Business Monitor; peer-reviewed medical research through the open access portal BioMed Central; and much more. The digital collection of Wits own research (staff and students) is hosted on WIReDSpace (Wits Institutional Repository on DSpace), with a full section of the repository dedicated to hosting electronic theses and dissertations, ensuring the long-term preservation of these research records. As in any university, the Wits Library is an important facilitator of research productivity through its e-services to the university research community (*coded as advantages of electronic resources*) (review of Wits Library website, 2013).

Typical questions that have arisen from Wits academics relate to the author's rights in copyright and open access publishing approaches (*coded as actor's rights*) (key informant Wits-L, 2014). This led to guidance on author's rights and addenda through presentations and brochures, based on the work of various libraries and publishing associations. A review of the Wits library website shows

the availability of exemplar addenda from the Boston Library Consortium, Harvard University, Massachusetts Institute of Technology, the Scholarly Publishing and Academic Resources Coalition (SPARC) and Science Commons (University of the Witwatersrand Library, n.d.d). Giving access to these 21 addenda is important for Wits authors publishing in international journals as the documents offer a font of knowledge from which to increase the certainty with which authors may approach a negotiation with publishers. The Wits addendum has provided the specific document for presentation to the publisher, while the exemplar addenda has provided authors with the grounds that modification to a publisher's standard copyright agreement is now more widely accepted than before, with these exemplar addenda dating from 2005 to 2009 (OAD, n.d.).

The library website has made available the Wits Addendum to Publication Agreement, the Author's Addendum for Publishers, guidance on negotiating an author's addendum with publishers, information on using Creative Commons licences, guidance on licensing open content and an information document on authors' rights in relation to publishers. The Author's Addendum for Publishers was designed to guide authors in terms of copyright law with respect to retaining the right to publish their work in the Wits electronic institutional repository, or other digital research repository, or on their personal or institutional website. This provides publishers with a 'non-exclusive licence' to publish the author(s) work, meaning that the publisher renders the formal publication for the purpose of providing a journal home or knowledge fraternity for the work, while the author retains the right to disseminate the information via other public platforms in the same (post-publication) or different (pre-publication or derivative) form.

Specific rights referred in the Addendum are (Wits, 2012c):

> Author's Retention of Rights ……. (i) the rights to reproduce, to distribute, to publicly perform, and to publicly display the Article in any medium for non-commercial purposes; (ii) the right to prepare derivative works from the Article; and (iii) the right to authorize others to make any non-commercial use of the

> Article so long as Author receives credit as author and the journal in which the Article has been published is cited as the source of first publication of the Article.

The Addendum explicitly required the publisher to provide the author with an electronic copy of the published article in a reusable format without restrictions that would "prevent copying or printing", noting that an even more explicit approach could address online dissemination in any form. A further level of complexity enshrined in the document related to any "pre-existing rights in the Article held by the Author's employing institution and/or by a funding entity that financially supported the research, noting that there may be specific requirements pertaining to publication in the applicable agreements.

8.3.2 Measures to advance open access publishing to scholars and scientists

The first and second OA week celebrations in 2010 and 2011 attracted only a small audience, mainly librarians, failing to make an impression on Wits academics in general. Presentations made to the URC in 2010 and to Wits SPARC in 2011 made a mildly stronger impact on consciousness (participant observation incident 6, 2011) and in early 2012 Senate adopted the decision to sign the Berlin Declaration.

During 2012, Wits staff and the leader of the open access platform at ASSAf, made a presentation to the Science Faculty Research Committee, while discussions were held with the Research Office leading to adoption of open access as a priority in the 2012-2017 research strategy (*coded as directed institutional strategy*) (Wits, 2012b, p.36):

> **Priority target 19: To embrace Open Access of publications**
>
> The global drive to make research publications freely available to the research community is an important development not only from the perspective of rapid access to research publications and hence productivity, but also exposing own research widely to the global community and hence enhancing its impact. For this purpose the Wits Library has established a portal referred to as the Wits Institutional Repository (WIReDSPACE). In addition Wits has also signed the

> Berlin Declaration, which commits signatories to adhere to and promote the Open Access principles. There is however certain administrative procedures that needs to be followed, in particularly those relating to copyright with the various publishing houses, such as the author's addendum to publication agreements. The Library is well positioned to provide the necessary assistance but lacks the capacity for full implementation, among others to defray the processing costs of articles published under Open Access. Provision is therefore made in this Strategy of an annual amount of R500 000 to assist the Library in this regard, akin to the arrangement regarding access to information from the Web of Science for our researchers. Full implementation does however require the participation of all researchers and hence it is proposed that the Research Office in conjunction with appropriate Library staff devise a strategy to achieve and to monitor this.

The Wits Library has been working to pull the published research of academics to WIREDSpace, but this has been a time-consuming process. There remains slow adoption of open access, concerns about peer review, quality, and what publishers would allow. The discussion with the Research Office about establishing an Author's Fund remained unresolved.

Many other challenges have been encountered. For example, for Wits staff working for the National Health Laboratory Service, Wits had to request permission from publishers to put copies of articles published by Wits authors on WIREDSpace. Some publishers allow pre-prints, while some allow post-prints. In a specific case, permission had to be sought to digitise a collection of articles in dental health going back to 1955. Copyright law doesn't allow digitisation, so the Library must check publishers' policies for every article (*coded as institutional policy and legal constraints*). Generally speaking, publishers don't want the articles digitised and widely accessible, due to the concern that this would undermine subscriptions. Hence, digitisation of Wits knowledge to populate the digital repository is a cumbersome process. Institutional policy would therefore be very useful to guide academics to publishing the pre-print manuscript version in the Wits repository, though the library will still check the publishers' requirements for embargo, or other restrictions (*coded as institutional policy guidance present or absent*).

8.3.3 Signing the Berlin Declaration and follow-up action

The most important presentation at the event to commemorate Wits signing of the Berlin Declaration, the Wits SPARC seminar in November 2012, was the presentation by Cochrane on open access publishing as a factor in building research profile and culture. Amongst the many demonstrations of the value of OA publishing was the evidence of the rapid increase in citation rates for mature researchers and others when including OA publishing in their repertoire (Cochrane, 2012). However, the ideas of open access scholarly publishing did not take hold at Wits during the ensuing academic year (*coded as institutional stasis*).

A year later, at the OA week seminar on 13 November 2013, participants reflected on the decreasing capacity to procure academic books and journals due to the fall in the exchange rate, despite the increase in the university budget, since the majority of books are bought in the dollar denomination. Other challenges cited include the South African Revenue Service (SARS) instituting value-added tax on books increasing the cost by ZAR8m for Wits alone. An idea was floated for a national indaba on library holdings and access to information to include VCs, the Department of Higher Education and Training, SARS and publishers to consider why the South African taxpayer cannot get access to the journal article that their taxes paid for (participant observer incident 12, 2013), all generating increasingly more complex dynamics for university management and for scientists.

8.3.4 A granular view of the values system and challenges of OA implementation

One of the protagonists in the open access movement at Wits had a long history of lobbying against copyright restrictions and the publishing industry's stranglehold on access to information. The values espoused by this protagonist were based in removing educational barriers as an anti-apartheid philosophy by challenging out-dated copyright laws in the late 1990's, thus building an interest in open access to information (*coded as open access to knowledge*). This key

informant reflected on the long-term concern of improving access, leading to involvement in many local, regional and international meetings, including the SARUA conference on opening access to knowledge in universities, held in Botswana in 2007, in collaboration with the African Access to Knowledge Alliance. The Botswana meeting resulted in a formal agreement that VCs would promote open access in their universities. However, this initiative did not mature, because there was no champion or resources for the Alliance to function.

Another view argued that the university was struggling to understand how OA can be championed and how it becomes a part of the mainstream work of the Research Office and of particular university structures, faculties and schools, where it fits in the university values system (*coded as institutional evolution*). There appeared to be a split view, with some arguing that OA publishing is extremely expensive, while others argue that it is not expensive and contributes to the citations. However, there has been no firm exposition of how Wits will support OA despite Priority 19 (key informant Wits-SM3, February 2014): "policy is one thing but if you don't channel resources then it gets unplugged from the mainstream conversation". One key informant reflected on the uncertainty about what to do with knowledge once it is produced and published, on the value of ownership beyond publication (*coded as contestation of values systems*)?

A further expression of this lack of clarity is confirmed in another interview (key informant Wits-SM1), who commented on the lack of understanding that open access was about scholarly publishing, because it had become confused with debates about open source software.

On reflection, it is possible that the university had a limited understanding of the meaning and nature of research visibility and did not fully understand how research visibility, researcher visibility and institutional visibility could be enhanced through open access publishing. Visibility is an important component

in a new paradigm of university values where institutions are concerned with the social impact of their knowledge as stated in the Wits IP policy 2012 (*coded as values: research visibility*). Nevertheless, the expression of research visibility as an explicit institutional value and the tactics of open access publishing in supporting such visibility are absent from the university documentation reviewed (*coded as research visibility; coded as evolution of institutional values system*).

8.4 Chapter summary: Insights for theory building from IP management and open access publishing

A few insights from this chapter: The values of the players making the advances and the values of the players contesting the advances in IP management and open access publishing are strongly opposed. However, strong opposing views and actions, such as openness versus copyright, or publishing versus patenting, can force a resolution and a shift to a different level of appreciation of the issues, to new values emerging and to a reluctant recognition of value. In some cases, where the value of innovation is not recognised at an institutional level, research actors find alternative modes of expression of these values, for example, the very large proportion of Wits academics self-archiving their publications on ResearchGate, but not on WIREDSpace.

Patenting, copyright and open access publishing can occur as parallel publication processes. While particular research actors confront particular limitations or constraints to their adoption or promotion of open access, there is accommodation of particular interests, though over a long timeframe, following participation in many quantum games.

Research actors experienced the difficulty of sustaining the momentum in highly complex or adverse situations. In attempting to push through adversity, the behaviour of actors is to theorise their experience in attempts to understand the resistant environment and keep change moving.

This chapter directed the author to the article on open access by Hanauske, Bernius and Dugall (2007), from whence the term entanglement was extracted and further explored and adumbrated. The chapter also highlighted a few forms of possible entanglement as expressed in Table 8.3 below.

Table 8.3 Forms of entanglement observed

Researcher-inventor entanglement in research production environment
Research-IP manager entanglement in commercialisation environment
Researcher-inventor: research-IP manager entanglement
Researcher-inventor: industry entanglement
Research-IP manager: regulator entanglement
Intra-university research entanglement
Inter-university research entanglement
Intra-university research funding entanglement
Inter-university research funding entanglement
Entanglement of actors and institutions
Entanglement of values and value

The brief overview of forms of entanglement suggests that the conceptual category of entanglement should not be given such broad meaning as it risks being made meaningless. The theoretical focus is being sought in this analytical process, hence the conceptual category of entanglement operates better at the highest level of conceptualisation, namely the broad category of university research entanglement, which is related to many sub-categories. These issues of conceptualisation of theory are discussed in more detail in Chapter 9.

Chapter 9 Grounded theory analysis of evolution in the university research sub-system: Theorising research entanglement

> *…exploration of entanglement, the seemingly telepathic communication between two separated particles—one of the fundamental concepts of quantum physics. In 1935, in what would become the most cited of all of his papers, Albert Einstein showed that quantum mechanics predicted such a correlation, which he dubbed "spooky action at a distance." In that same year, Erwin Schrödinger christened this spooky correlation "entanglement." Yet its existence wasn't firmly established until 1964, in a groundbreaking paper by the Irish physicist John Bell* (online review of The Age of Entanglement[23]).

9.1 Arriving at the content of the theory: iterative process of following the data and theory building

The theory generated from the qualitative research data presented in Chapters 4 through 8 was based on an iterative process of following the data, theory building, theory testing and final statement of the theory. The theory of positioning universities in emerging knowledge economies towards greater research activeness and research intensiveness utilises the concept of entanglement as expressed in quantum physics to formulate a way of thinking about the intangible relationships, forces and influences that can be observed amongst five contributing elements: research actors, research-oriented institutions, research resources, research values, and research value. Research entanglement is a metaphor for the actions, behaviours and events that occur when researchers/scientists and universities make good progress towards greater research activeness in adverse and complex environments. The theory will be explained in greater detail below and in the final chapter.

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[23] Available 26 August 2013 at http://books.google.co.za/books/about/The_Age_of_Entanglement.html?id=O22xnhCSIrkC&redir_esc=y

9.1.1 Processing the data and early identification of categories and theoretical elements

The beginnings of the formal process of theory building commenced with the emergence of the categories of values and value, which grew out of the first phase of research conducted in 2008. There were a few dead-ends in the grounded theory process. The initial thinking in 2007-2008 was to explore contributions to and benefits from participation in the knowledge economy, but this would create an understanding of the content and possibly the impact of research, rather than the complexity of research production at universities. The initial analysis from the Indian study was presented at the Higher Education Close-Up 4 conference in 2008, which received the response that residential universities could not work in South Africa. The conference content was largely about the pragmatics of higher education, rather than system level thinking about change in universities. This dead-end led to the co-authored conference paper on higher education values and value, in an attempt to explore ideas for building theory.

The observation of values and value as possible theoretical categories resulted from the process of reviewing the data collected in the Indian higher education sector and the initial studies at the University of the Witwatersrand (economic geology and mining exploration; software engineering, globalisation and culture; rural health research and the engaged university). When these categories were identified in the data, the author examined the readings of Aristotle, noting the importance of the notion of a "habitual state" of developing "practical wisdom". The review of related literature when identifying potential elements of theory is consistent with grounded theory methodology according to Christiansen (2011, p.21), who notes "relevant literature for conceptual comparison cannot be identified before stable behavioural patterns have emerged".

This early data and analysis was presented at the Society for Research on Higher Education conference on Valuing Higher Education in 2008 and published in 2012. The article explored the Aristotelian concepts of values and value and their relatedness with respect to changing values systems in the university (Abrahams & FitzGerald, 2012, pp.4-5):

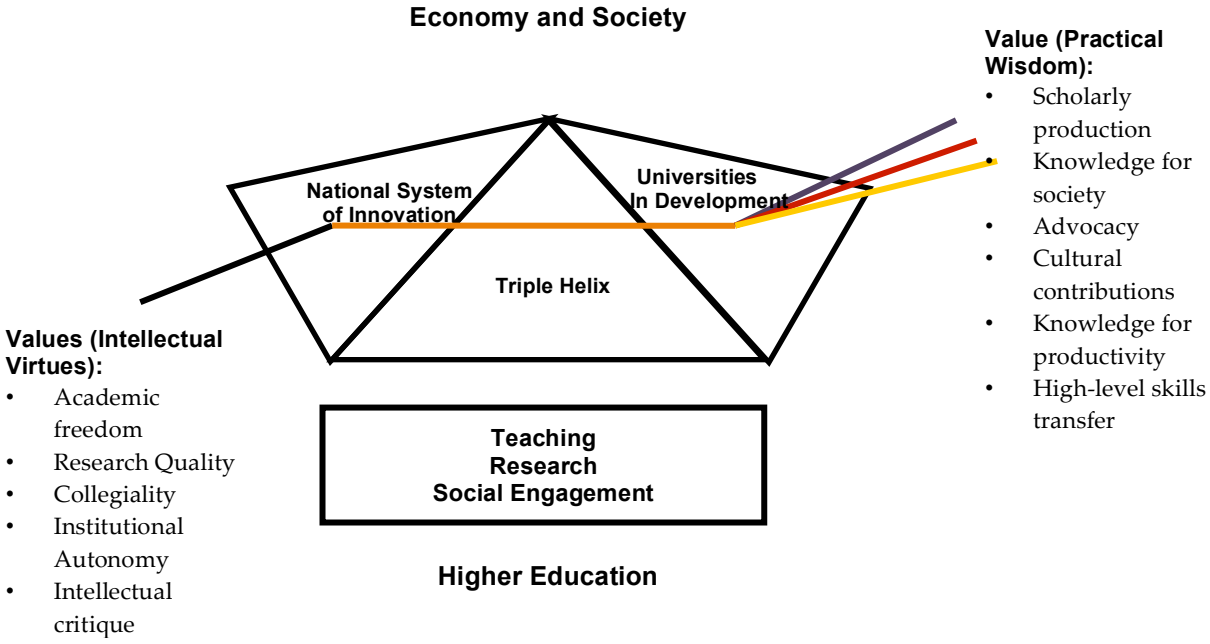
> Now, if the aim is noble, then cleverness is praiseworthy; if it is base, then cleverness is just unscrupulousness. So we describe both people of practical wisdom and those who are unscrupulous as clever. But practical wisdom is not just cleverness, though it does require cleverness. It is a habitual state which is developed in the eye of the soul only in the sense of moral virtue... (from Aristotle VI, 12, 1144a26-b1) ([15], p. 106).
> Hence, for Aristotle, wisdom capable of linking good values to added value is very different to an isolated ethical decision based on abstract principle, but is rather the constant mapping and verification of a practical terrain. Thus, iterative good practice based on sound values engenders applications appropriate to the given context and therefore is capable of reliably generating value within a multi-dimensional continuum linking enlightened self-interest to civic-mindedness.

This early assessment of the relationship between values and value argued that a new epistemology of values and value was evolving (Abrahams & FitzGerald, 2012):

> How does the perceived relationship between values and value affect management, leadership and governance? University leaders are accustomed to knowledge entering society through certain well-established protocols and ensure that there are sufficient protections against instrumentalism, narrow economic interests, censorship, short-termism, populism or attacks on academic freedom. However, in the new landscape of knowledge formation, these boundaries have become porous with values and value bleeding across them. The received package of values is no longer a comfort zone, but an arena of tempestuous doubt, open to challenge, negotiation and reorientation.

The ideas pertaining to the evolving values system were represented in the diagram in Figure 9.1 below, illustrating the transition from intellectual virtues (values system) through the prism of knowledge economy formation (national system of innovation, triple helix, universities in development practice) to practical wisdom (value, or application of knowledge).

Figure 9.1 Translating values to value in higher education



Source: *Abrahams & FitzGerald, 2012*

The ideas pertaining to values and value were insufficient as an indication of the dimensions and trends with respect to research production and the positioning of the university research sub-system. However, the theorisation of values and value led to the identification of the case studies of the Agincourt Unit and the JCSE as institutional segments, which if tracked over the period of the study, could yield useful data and analysis for theory building with respect to universities in the knowledge economy. A retrospective view of the early data highlights the presence of the categories of research actors, research-oriented institutions and research-oriented resources, which were only identified at a later phase of data collection.

In a parallel endeavour, given the study interest in new phenomena and new values in universities, the researcher led a separate study on opening access to knowledge in Southern African universities through building open knowledge

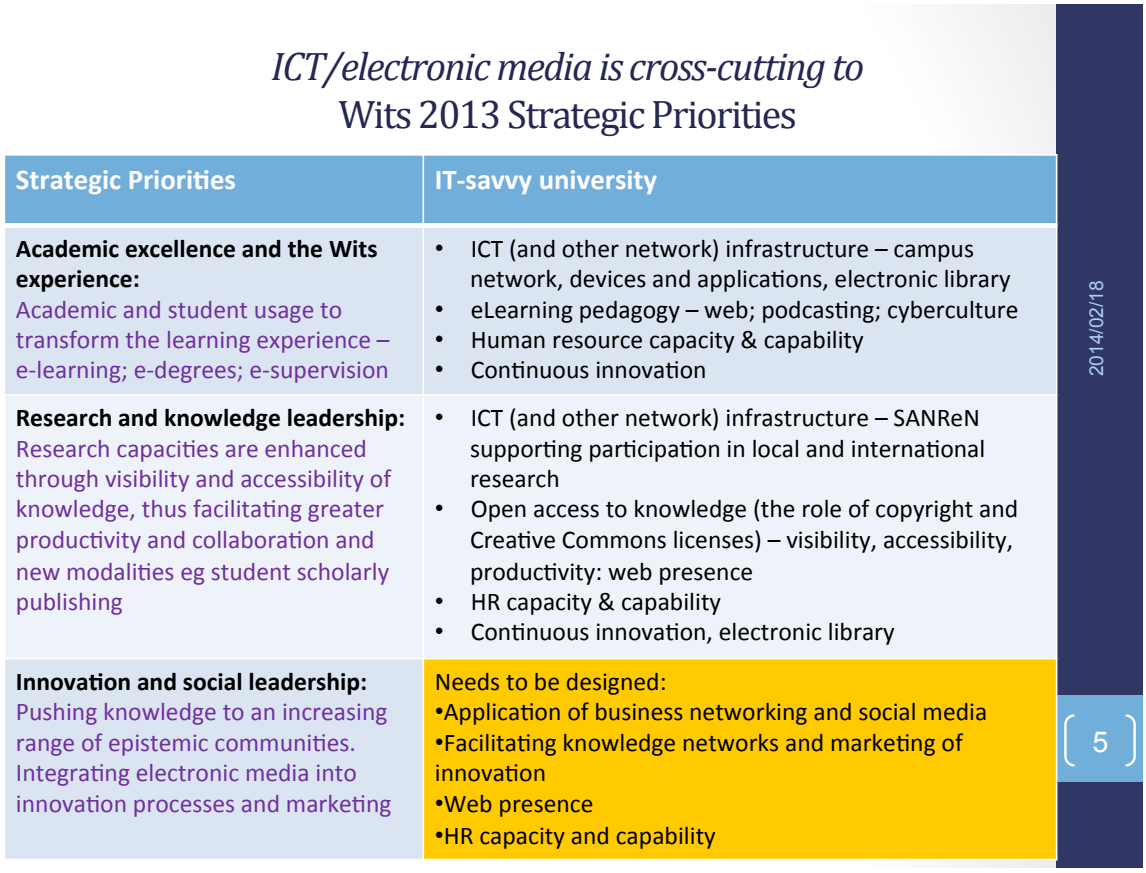
platforms for scholarly communication (Abrahams, Burke, Gray & Rens, 2008). This work was published as a theorisation of the relationship between research productivity, visibility of research and accessibility of scholarly communication in Southern African universities and fostering open access approaches to make scholarly communication visible and accessible through the Internet (Abrahams, Burke & Mouton, 2010). The observation that many universities were practising very limited forms of open access to scholarly communications, and that therefore the available bodies of knowledge produced in universities were not accessible to researchers, academics and students, while publicly funded research was being tied up in copyright, led the thesis study in the direction of exploring the case of open access in scholarly communications at Wits, the case study institution.

Having followed the data on the early open access movement at Wits, it was observed that open access crossed paths with the responses of the university to the IPR-PFRD Act, 2008 pertaining to the protection of intellectual property rights. The recognition of the confluence of open access publishing and management of intellectual property rights led to the choice of the third case study, a study of institutional process, values and value.

Data from the five cases studies were collated and organised using open coding, leading to identification of the main categories for grounded theory building as being research actors, research-oriented institutions, research resources, values systems and research value, each with a number of associated sub-categories as set out in Table 9.1 below.

In the continuing search for ways to build the data profile and the possible grounded theory for the study, various presentations were offered at Wits, including a presentation on e-universities, see sample slide in Figure 9.2 below (participant observation incident 6, 2011).

Figure 9.2 Contemplating e-universities



Source: *Abrahams, 2011, presentation to Wits SPARC meeting*

9.1.2 Presentation of open coding for main categories and sub-categories, inductive and counter-inductive analysis

The exploratory research conducted in India led the author to think about the nature of observation as a process of 'looking out from the inside' (a South African looking at change in Indian HEIs) and 'looking in from the outside' (a South African based at an Indian higher education institution for a few months, looking at a South African university from the perspective of researching change in Indian universities). With respect to interpreting the data, the author considered counter-inductive analysis prior to reading Feyerabend's (1993) thesis, because even inductive analysis seemed to require too logical an approach to explanation and theory building. The author was searching for ways of seeing change that did not rely exclusively on logical explanation, because her experience of change is that it is far from logical and that theories built on

apparent logic often rely on a narrow perspective of the observed data. In institutional systems and institutional change, people and institutions often confound logical analysis by behaving in ways that are not a simple progression along a clear path. Thus, Table 9.1 below includes the sub-categories directly observable from the data (as coded in Chapters 4 through 8) such as institutional strategy limitations, as well as "counter categories" that could reasonably be said to be an alternative position from the apparent mainstream position, such as co-evolution of strategy with structure.

The open coding continued to expand through a significant period of the study from 2008 to 2013 as data was collected and the narrative of the study emerged. The main categories and sub-categories were relatively easy to determine, because the main categories operate at a generalised level, while the sub-categories enable understanding of each category at a more specific level. The sub-categories are not explained at an intense level of detail in this chapter, because their meaning has been generated from the data narrative provided in the relevant chapters 4 through 8. The open coding presented in the text represents theoretical saturation (Holton, 2010, p.32) as required in grounded theory, however the list of open coding presented in Table 9.1 is indicative rather than exhaustive. For the purposes of grounded theory, the detail of people, time and place are no longer relevant during the theory building process (Glaser, 2002), as the theory should be broadly conceptual and function at a high level of applicability.

The positioning of women in science as a research interest was not pursued in the thesis, nor were the categories of triple helix, entrepreneurial science, talent, gender, race, because these categories relate to "how universities do research production" and "who produces research", rather than to "why universities transform or do not transform their research capability".

Table 9.1 Categories and sub-categories arising in open coding

CATEGORIES	SUB-CATEGORIES (basis for detailed analysis and establishment of patterns pertaining to research entanglement)	
RESEARCH ACTORS (conditions)	Inductive reasoning	Counter-inductive reasoning
	Actor contestation Power of actors Actor resistance Adaptability of actors	Electronic intelligence Mis-explanation Re-explanation
	Resolve of actors Coincidence of actor interests	Dissimilar behaviour of actors Differentiation among actors Limitations of actors
RESEARCH-ORIENTED INSTITUTIONS (conditions + strategy)	Inductive reasoning	Counter-inductive reasoning
	High impact institutional change Institutional evolution Institutional stereotyping Co-evolution of strategy with structure Institutional strategy limitations	Institutional complexity Global institutional complexity Institutional governance complexity Coincidence of interests of institutions
	Global institutional linkages Local institutional linkages	Institutional futurism Institutional design Institutional fracture Institutional collaboration
RESEARCH RESOURCES (conditions)	Inductive reasoning	Counter-inductive reasoning
	Resource availability Resource application/utilisation Resource sustainability Resource generation	Resource scarcity: time, infrastructure
	Resource capacity Resource competition Resource equity	Resource capacity building Increasing resource demand High capacity resource demand High capacity resource supply
RESEARCH VALUES SYSTEM (conditions)	Inductive reasoning	Counter-inductive reasoning
	Innovation orientation Indigenous science orientation Multi-disciplinarity Open science Open access to knowledge	Intangibility of strategy Coinciding values paradigms Contesting values paradigms Non-traditional values Traditional values

	Research visibility (open access publishing) Sustainable urban design Inner city renewal	
	Institutional innovation Institutional chaos Self-reflection	Socio-cultural inhibitors
RESEARCH VALUE (consequences)	Socio-cultural value Socio-economic value Social value defined Social value derived Social value hidden	Economic value derived Commercially relevant value
	High capacity creators of science Scientific capacity building Unrealised value	Value of communications infrastructure and e-services Value of research infrastructure

A key analytical point here is the strong emergence of new (non-traditional) values such as open access, research visibility, sustainable urban design and inner city renewal as values of academics and of the university. Despite contestation over and resistance to these values, they have become established values in a relatively short space of time.

9.1.3 Key considerations in theory building

One of the key considerations in theory building was the interpretation of these categories in ways that would enable theory building to interpret what guidance the data was giving. An interesting observation was that data from the India exploratory study from the case study institutional overview and from the three distinct in-depth case studies had become convergent. Researchers and scientists at universities in India and in South Africa experienced complexity and adversity in the performance of research and sought to make progress against adversity. In this they were assisted by their curiosity and by their individual and institutional strategic interests. In another example of convergent events, the JCSE interest in data science was becoming connected with the Agincourt interest in analytics capacity for "big data", while the SANReN Internet infrastructure had evolved to

provide the requisite data storage capacity. It appeared that pushing through adversity had some important results, which included opportunity for convergence of strategic interests among key research actors over time.

Methodological considerations thus became important as a means to undertaking the next phase of theory building, in particular the potential usefulness of counter-inductive analysis as a supplementary approach to inductive reasoning. Feyerabend's (1993) published "letter" on counter-inductive analysis sets out explicitly and in detail certain facets of a counter-inductive approach to theory building. Feyerabend's thesis can be summarised as follows (Feyerabend, 1993, pp.39-53,): The process of theorisation is not about arriving, in one piece of research, or in one era of research, at a complete theory of the whole, as suggested in many grounded theory textbooks. The process of theory building is flawed and often goes through multiple iterations in which initial theories may contradict observable evidence, yet still find sufficient purchase to influence the later explication of theory that emerges when further evidence is gathered. Theory is fallible he argues, even the best theory. Theory can be built using inductive analysis, but can also be built using counter-inductive analysis. He states [author's note: this is a deliberately long quote which is deliberately not summarised] (Feyerabend, 1993, pp.49-50):

> …we find that theories fail adequately to reproduce certain *quantitative results* [author's note: he is referring to the special theory of relativity and the general theory of relativity which both fail under certain conditions], and that they are *qualitatively incompetent* to a surprising degree…Modern science has developed mathematical structures which exceed anything that has existed so far in coherence generality and empirical success. But in order to achieve this miracle all the existing troubles had to be pushed into the *relation* between theory and fact, and had to be concealed, by *ad hoc* hypotheses, *ad hoc* approximations and other procedures. This being the case, what shall we make of the methodological demand that a theory must be judged by experience and must be rejected if it contradicts accepted basic statements? What attitude shall we adopt towards the various theories of confirmation and corroboration, which all rest on the assumption that theories can be made to agree with the known facts, and which use the amount of agreement reached as a principle of evaluation? This demand, these theories, are now all seen to be quite useless…Is it possible to proceed in a

> more reasonable manner?... According to Hume, theories cannot be *derived from* facts. The demand to admit only those theories that which follow from facts leaves us without any theory. Hence, science as we know it can exist only if we drop the demand and revise our methodology. According to our present results, hardly any theory is *consistent with* the facts…Hence, a science as we know it can exist only if we drop this demand also and again revise our methodology, *now admitting counterinduction in addition to admitting unsupported hypotheses*.

This view is similar to that expressed by Glaser (2012, p.4-5) who expresses the need for the researcher to generate the core category and the beginning theory, rather than take responsibility for extensive theoretical coverage of the subject, which is not possible in a single study. This study therefore uses both inductive and counter-inductive reasoning to build an initial theory with respect to the evidence gathered.

To reiterate the methodological discussion pertaining to theory building: Open coding was used to identify the categories and sub-categories that arose from the data collected by participant observation, document review and responses of the key informants, with attention to categories that reflect on conditions, on strategies and on consequences (Table 9.1 above). Open coding was conducted throughout the research process, in order to direct further data collection. Inductive reasoning was used to think about and define categories and sub-categories that emerge from the data (in other words to think about what the data represents), and counter-inductive reasoning was used to look for alternatives themes and patterns that may not have been identified in the data or that may arise in a theoretical case. Counter-inductive reasoning was not used extensively, but is present in the coding process.

The categories and sub-categories in the open coding section were continuously analysed to assess which of these constituted the possible core category related to the other elements (actors, institutions, resources, values, value). The categories of values and value had been considered at an early stage of the study, but

neither category suggested itself as core. In the course of the case study research on open access publishing and intellectual property rights, which occurred towards the end of the iterative data collection and coding process, the researcher encountered a particular concept in the open access literature that evoked interest in relation to the observations of complexity, adversity and strategic interest in the data with respect to universities working towards research activeness or intensiveness. The concept of entanglement in quantum games in the practice of open access publishing (Hanauske, Bernius & Dugall, 2007) pointed to the potential value of quantum game theory and concepts from quantum physics in understanding the emergence of new scientific models and approaches. Hanauske, Bernius and Dugall (2007, p.10) argued that:

> [in] quantum game theory parlance one would say, that scientific disciplines, like mathematics and physics, which had been successful in realizing the open access model, consist of scientists, whose strategical operations are strongly entangled. In contrast, if a scientific community is still imprisoned in the Nash equilibrium of non-open access, there would be a lack of entanglement between the strategical choices of the related scientists of the community.

Considering the data from this study as a whole, in the light of the ideas about entanglement between strategical choices, it is suggested that entanglement could be articulated as a much greater phenomenon operating at the level of each of the five identified categories (actors, institutions, resources, values and value), not only at the level of actors. In other words, entanglement could be utilised as a metaphor (trope) for the processes occurring in a university when a vast array of simultaneous interactions leads to formation of new processes and outcomes, just as in quantum physics when the rapid collisions amongst particles give rise to miniscule, invisible, but ultimately impactful change in the atom (Schrödinger, 1935). Thus, while in the Hanauske, et al (2007) view, scientists are entangled in particular strategical conditions, the data with respect to the complexity of universities positioning themselves for greater research activeness is indicative of research actors and institutions being engaged in quantum research games, in ways that generate a state of research entanglement. The infinite number of

collisions taking place as actors, institutions, resources, values and value collide, in the temporal state where universities seek the environment necessary for consecutive transitions to heightened research intensity. The data further suggests that particular research actors and universities seek such entanglement as a means to pushing through adversity and resolving complexity. Some of the results of research entanglement noted from the data include (i) the convergence of interests across actors and institutions over time, and (ii) achievement of intended objectives of the research actors or institutions for increased research activeness or intensiveness, despite earlier adversity or contestation.

At this point in the research, a number of analytical perspectives have accumulated: counter intuitive behaviour of university-based scientists – entrepreneurial science is only a limited perspective (Etzkowitz); understanding of relationship of values to value, and the notion of an habitual state of creating value (Aristotle); the contribution of counter inductive analysis (Feyerabend); and the idea of entanglement drawn from quantum physics (Schrödinger). Of these analytical perspectives, entanglement has what Glaser (2002) refers to as "grab" or attraction for the researcher. A search for other uses of the concept of entanglement leads to concepts of the entanglement of human and technological activities, socio-materiality in web search and in social media, and entanglement in practice (Orlikowski, 2009; Orlikowski & Gash, 1992; Orlikowski & Scott, 2008). None of these perspectives explains the observations and analysis arising from the open coding of the data. The concept of entanglement is therefore introduced into the axial coding of data to enable consideration of its explanatory power.

9.2 Second phase of theory building: Axial coding of inter-relationships

Axial coding is used to think through the relations of categories to each other as a process leading up to theorising the holistic category. Axial coding is used to make connections between and among the various categories and sub-categories

in order to identify mainstream views and alternative views expressed, see Table 9.2 below. This enables the design of a grounded theory model as proposed by Babbie & Mouton (2001, p.498-501), setting out: (a) causal conditions; (b) phenomenon; (c) context; (d) intervening conditions; (e) action/interaction strategies; and (f) consequences. This approach is applied to ground the concepts that arise in the study. The axial coding is set out in Table 9.2 below.

Table 9.2 Axial coding: relationships among the main categories

AXIAL CODING	MAINSTREAM AND ALTERNATIVE PERSPECTIVES
Research actor – Research actor	**Mainstream perspective** Research actors face high levels of adversity and seek to proceed to higher levels of research entanglement, as a means to moving through states of difficulty. Contestation at an individual level is rarely about individual research actors, but is more often about resources, or institutional culture, or alternative views of the knowledge universe, or contestation of values applicable to research. **Alternative perspective** Research actors can be lone rangers, or can be catalytic to each other. Research actors seek to disentangle themselves from the complexity of research practice.
Research actor – Research-oriented institution	**Mainstream perspective** Research actors can catalyse organisational change processes to foster research, intentionally and unintentionally. Research actors engage in behaviour that is catalytic to research practice in institutions, whether they experience direct benefit or not, whether they experience short-term benefit or not. **Alternative perspective** (counter-inductive reasoning) Actors selfishly pursue their research interests to the mutual advantage of the actor and the institution. Comment: This is an interesting aspect of the relationship between actors and institutions because the alternative perspective has historically held the upper hand.

Table 9.2 Axial coding: relationships among the main categories continued

AXIAL CODING	MAINSTREAM AND ALTERNATIVE PERSPECTIVES
Research actor – Research-oriented resources	**Mainstream perspective** Financial and human resources are the top priorities of research actors, who often act like the sorcerer in the tale of the sorcerer's apprentice, manufacturing the human resources needed to undertake particular research. **Alternative perspective** (counter-inductive reasoning) Research actors await the annual competition for internal and external resources and compete for a pre-defined basket of funds.
Research actor – research values	**Mainstream perspective** The idea of anticipated value is often sufficient for research actors to find entanglement attractive. Contestation of academic values old and new is common among research actors. **Alternative perspective** (counter-inductive reasoning) Anticipated value is unattractive to research actors, while real value is seen to be beyond the reach of many.
Research actor – Research value	**Mainstream perspective** Research actors have a wide contemplation of the meaning of value, what constitutes value to which groups under which conditions. **Alternative perspective** Researchers retain a view from a previous historical era that publications, citations and impact factors are what constitutes value, partly because of the self-reinforcing nature of resources flowing to these forms of value.

Table 9.2 Axial coding: relationships among the main categories continued

AXIAL CODING	MAINSTREAM AND ALTERNATIVE PERSPECTIVES
Research-oriented institution – Research resources	**Mainstream perspective** Institutions confront resource scarcity and make choices on which research projects to support based on low risk and historical evidence of return on investment. **Alternative perspective** (counter-inductive reasoning) Institutions must spread their investment risk in order to gain value from uncharted research territory.
Research-oriented institution – Research values	**Mainstream perspective** The wide range of values operating in practice diverge from or supplement the documented values of the university with respect to research. **Alternative perspective** (counter-inductive reasoning) The values elaborated in institutional strategy documents are the driving values for research.
Research-oriented institution – Research value	**Mainstream perspective** The institution understands value largely as an internal impact or consequence of research. **Alternative perspective** (counter-inductive reasoning) Parts of the institution understand value largely as external impact or consequence of research, with feedback loops to internal value.
Research-oriented resources – Research values	**Mainstream perspective** Not easily discernible from the data. **Alternative perspective** (counter-inductive reasoning) Not considered.
Research-oriented resources – Research value	**Mainstream perspective** Application of resources results in numerous forms of social, economic and cultural value, too many to be enumerated and all sought after. **Alternative perspective** (counter-inductive reasoning) Application of resources results in academic value.

Table 9.2 Axial coding: relationships among the categories continued

AXIAL CODING	MAINSTREAM AND ALTERNATIVE PERSPECTIVES
Research values – Research value	**Mainstream perspective** Contestation of values and value is high, while alignment of values and values is low. The values associated with increasing participation in research and innovation fosters value through practical outcomes in academic terms, in social terms or economic terms, though in reality academic value remains higher than social or economic value as universities have limited power to socialise or commercialise research. **Alternative perspective** (counter-inductive reasoning) Not considered.
Research actor – research-oriented institution – research resources – research values – research value	This is the whole and will be discussed in the ensuing sections on theory building.

From axial coding, the next section presents a discussion of causal conditions in Table 9.3 below.

Table 9.3 Categories and causal conditions

MAIN CATEGORIES	DISCUSSION OF CAUSAL CONDITIONS
Research actors – Institutions	The power of actors to overcome complexity and adversity, to move beyond mis-explanations of research related ideas and attempt re-explanation enables them to push through adversity. While there is differentiation among actors with respect to managing adversity, the coincidence of actor interests enables universities to move towards greater research activeness or intensiveness.
Research-oriented institutions – Values	Universities experience co-evolution of strategy with structure as actors build the future structures and institutional design, despite existing strategy limitations and institutional governance complexity.
Research resources – Research actors	Resource availability or scarcity are key factors influencing competition for resources and leading research actors to engage in quantum research games to access or generate resource capacity over the long run. However the demand for high capacity resources

	exceeds supply, creating risks for resource sustainability.
Research values – Value	Traditional values and non-traditional values are present, while contesting values appear to be as prevalent as coinciding values. Contending values systems suggest varying outcomes in terms of social or economic or academic value.

The question that arose in relation to clarifying the phenomenon was how to formulate the object of study. The phenomenon could be interpreted as complexity and adversity experienced by research actors, or as actors playing quantum research games, or as the result of quantum games being research entanglement, hence the discussion in Table 9.4 below.

Table 9.4 Elaboration of phenomenon

PHENOMENON	DISCUSSION
Entanglement of research actors in complexity of change	In the Hanauske et al. (2007) view, scientists (in mathematics and physics) are entangled in their strategical operations and utilise the particular mechanism of open access publishing to advance knowledge. In this thesis, research actors from many components of the university, health sciences, engineering sciences, social sciences, library, infrastructure and other components that together constitute the university research sub-system, find themselves entangled or engage in entanglement in the complexity of change with respect to five particular categories of complexity. The choices faced by research actors are to be attracted to entanglement or to be attracted to anti-entanglement. *Both entanglement and anti-entanglement are reasonable and necessary propositions for specific actors.*
Entanglement of research universities with complexity of change	Universities seeking to transition towards greater research intensity find that this endeavour is one that is constituted of entanglement in five particular categories of complexity – the endeavour of increasing research intensity requires entanglement of research actors, with research institutions, with research resources, with research values, and ultimately with the creation of research value. *Anti-entanglement is not a proposition for the research university as a whole.*
Entanglement of research actors with universities	While some research actors find entanglement, other research actors seek entanglement, and yet other actors shy away from entanglement in the complex processes of the university endeavour to increase research production, though all actors may contribute to research production. Some research actors will participate in only the most limited ways in research production.
Entanglement of values and value	This particular form of entanglement of research values with the creation of research value is analogous to the Schrödinger's cat theory. It is not known which research values will lead to what forms of research value. Irrespective of which values are stated in research and institutional strategy, it is unlikely to be possible to determine whether and to what extent these stated values resulted in the creation of particular forms of value. *It is therefore necessary to understand the practised values that underlie the behaviour of research actors and the research university, rather than those elaborated in strategy documents.*

Table 9.4 Elaboration of phenomenon, continued

PHENOMENON	DISCUSSION
Positioning universities for research activeness or research intensiveness	Practised values can also be interpreted as lived strategy. Universities and scientists/researchers seeking greater research activeness, seeking to advance their fields of research are attracted to complexity and appear to constantly engage in positioning actions, which can also be described as participation in quantum research games leading to a state of research entanglement.

The ensuing discussion, presented in tabular form, thinks through the contextual features, the intervening conditions, the action and interaction strategies, and the consequences pertaining to the axial coding of inter-relationships, see Table 9.5 to Table 9.8 below.

Table 9.5 Discussion of context

CONTEXT	DISCUSSION
Emerging knowledge economy	Universities are no longer operating in a 20th century context, though much of the conversation remains a 20th century conversation. Thus, universities seeking greater research activeness mark their knowledge territory by making explicit references to 21st century knowledge production. Individual parts of the university are redefining the conversation to be a comprehensively 21st century conversation. The external demands for scientific and applied research are increasing and universities are explicitly understood to be knowledge producers for society and economy. The required level of research intensity, quality assurance and research management is set at a high bar.
National policies and influences on universities in a development context	National science and technology policy places a high value on university-based research production, and provides highly selective, highly competitive funding. National higher education policy places a basic value on university-based research production, and provides some income flow for research practice and publication.
Global research quantum games	There is extensive global competition in knowledge production with the explicit objective of attracting research funds from large donors and for ground-breaking research. Universities in emerging economies and on the African continent are poorly prepared for participation in these global research quantum games. These global research games include the complex helix phenomena of multiple research relationships among multiple research actors.
National system of innovation	The broader national system of innovation constituted of R&D activity in industry, scientific performing agencies, national research facilities, R&D funding agencies and universities offers opportunities and constraints to research-based knowledge production.

Table 9.6 Discussion of intervening conditions

INTERVENING CONDITIONS	DISCUSSION
Research actors	Electronic intelligence provides information flows among research actors and provides data for decision-making to research actors, thereby influencing the relative ease with which they can address complex situations and the networks that can be called upon to create a supportive environment.
Research-oriented institutions	The risk of a variety of forms of institutional fracture or institutional instability is high in highly entangled environments and may intervene in efforts to promote greater research intensity. Socio-cultural inhibitors may be present, such as various forms of conservatism, bureaucracy or hierarchy.
Research-oriented resources	Resource equity may or may not be established at particular points in time over the course of a decade or more of transition to increasing research intensity. Increasing resource demand means that the goal posts for resource attraction are always shifting, and when a particular goal has been achieved, the next goals will be to achieve a greater volume of research resources.
Research values	Particular values appear in the data to offer important intervening conditions that may foster advancement of research, such as: Innovation orientation Indigenous science orientation Multi-disciplinarity Open science Institutional innovation or chaos Self-reflection Intangibility of strategy

Table 9.7 Discussion of action/interaction strategies

ACTION/ INTERACTION	DISCUSSION
Research actors	Actor strategies are not elaborate and appear to be "honest" responses to the prevailing circumstances, including working with contestation, pressing ahead despite resistance, pushing through adversity.
Research-oriented institutions	Institutional stereotyping can make emulating or copying other research-intensive universities or institutions seem attractive, on the understanding that such copying will lead to greater research intensity. In reality, simple copying of approaches may be a sub-optimal approach.

	Global institutional linkages and local institutional linkages and formal collaboration are key strategies for fostering advances in research volume and quality. Multi-disciplinary research is a key strategy to advance research intensiveness.
Research-oriented resources	Interaction strategies with respect to resource generation and resource utilisation are both collaborative and competitive. Resource capacity building is seen as a necessary strategy.

Of the many potential consequences to consider, Table 9.8 highlights the consequences that arise from the data, where institutions and actors are highly entangled with each other.

Table 9.8 Discussion of consequences

CONSEQUENCES	DISCUSSION
Research-driven institutional change (greater scientific research capacity, high capacity creators of science value for society, other)	Institutional change is not driven by strategy or by formal initiatives to effect institutional change such as change management, rather institutional change is effected by how the practice and dissemination of research, as well as societal responses (from other universities, funders, partners and society) changes what the institution does, how it thinks, how it conducts its business. Change is less a management process than a culture change effected by the influences of research driving different behaviours and decisions in the institution.
Intensification of knowledge production	The process of intensification of knowledge production becomes intrinsic to the culture of the institution, an Aristotelian habitual state. Increasing numbers of actors seek to participate in the culture of knowledge intensification with or without incentives. The trend in knowledge intensification is towards innovation and the commercialisation of IP, as well as the socialisation of IP, outcomes of the intensification of research.
Forms of value creation through research	The institution is engaged in multiple forms of value creation, which cannot easily be restricted to research, teaching and community engagement. Alternatively, the meanings of research, teaching and community engagement have been re-understood as being more than publications, classes and public seminars. Forms of value include socio-cultural value, socio-economic value, social value defined, social value derived, social value hidden, social value deferred, economic value derived, commercially relevant value, return on investment in ICT research infrastructure.

Acknowledgement of the value of knowledge	The institution no longer questions the value of knowledge intensification through research. The institution has moved to a place where the knowledge production demonstrates its value to society and economy and the future challenges are associated with the constant promotion of value.
Potential for systemic change in the higher education system	As individual higher education institutions begin to exhibit or engage in greater research-intensive activity as compared to their previous research history, research-driven change begins to have system effects, not limited to institutional effects.

9.3 Third phase of theory building: selective coding and prelude to theoretical framework

Selective coding is employed to identify the core category and to systematically relate the other categories to this core category, supported by explanation of the relationships (Glaser, 2002). This process of selective coding is the discovery process that creates the storyline for the object of study and provides the basis for detailed analysis and establishment of patterns (Babbie & Mouton, 2001, p.p.500-501). Finally, a theoretical framework is developed, grounded against the data (Charmaz, 2000, p.510).

By this stage of the study, in 2013 (having conducted iterative data collection and coding for an extended period), it was apparent that the novel aspects about the trends, tropes and positioning of universities in the knowledge economy were not about "what" universities were doing, rather it was about how they achieve success at what they are doing. Some universities experienced decadal transformation, leading to the formation of an entirely new form of the institution "university", while others remained in the same historical niche for at least a decade without change.

As the data became formulated into stable categories through the final write up of the narrative and the open and axial coding with respect to the three in-depth case studies (behaviour of research actors, behaviour of research-oriented institutions, accessibility of research resources, effects of research values systems

and value realised or unrealised), the question arose pertaining to what should be considered the core substantive category, namely the category that is at the centre of the theory and that holds relationships to other lower level categories. A possible core category was perceived as adversity, because the exploratory study in India, the detailed open coding and axial coding for the case study institution, raised the phenomenon of researchers and institutions pushing through adversity as an important theme. However, "pushing through adversity" was discounted as a core category, because it was too generalised a statement, though complexity and adversity are retained as theoretical concepts that assist in the explication of the theory.

As stated above, an important task following from the open coding and axial coding was to resolve which was the core category and which were the related categories of the theory. **The overarching category on which the theory would be based was chosen as: Positioning universities for research activeness through research entanglement.** This was chosen as the overarching category because it offered the best conceptualisation of the phenomenon to which the theory pertains and was influenced by the five underlying categories – research actors, research-oriented institutions, research-oriented resources, research values and research value. The concept of entanglement that originates in quantum physics, and which has been utilised in a number of subsequent theories, can be re-interpreted to be used as the core category to enable understanding of university transitions to research activeness and intensiveness, as discussed below. There are many forms of university research entanglement and the phenomenon is therefore discussed with respect to a few observations.

Table 9.9 Discussion of the holistic theory of entanglement

THEORY: FORMS OF ENTANGLEMENT	DISCUSSION
Entanglement	**Mainstream views:** Entanglement is a phenomenon observed or experienced by many research actors. The nature of the relationship between the phenomenon (entanglement) and its elements (research actors, research-oriented institutions, research resources, values system and research value) is such that the effect of any element on the other cannot be predicted with certainty. However, entanglement is desirable as it encourages research intensiveness.
Anti-entanglement	**Alternative views:** Entanglement can exhaust the capacities and resources of the research entity or university and should be balanced with the stabilising force of anti-entanglement.

9.4 Elevating "entanglement" to a theoretical construct with respect to university research activeness and intensiveness and other uses of entanglement in scholarly writing

The discussion that has arisen in this thesis relates to how the institution meets its ambition of being a university in a 21st century knowledge economy through increasing its research activeness or its research intensiveness, requiring greater emphasis on the research sub-system of universities. This endeavour is not simply about moving the institutional task from teaching to research production, from knowledge transfer to knowledge production. The endeavour is about understanding the trends and positions that enable such a change, a scaling up of research activity, and finding ways of encouraging or joining the trend where this is considered desirable.

Once the category entanglement had been considered in relation to the other categories in open coding and entanglement had been selected as the holistic category for theory building, the author searched extensively for scholarly writing on entanglement, being directed mainly to the fields of quantum physics,

quantum game theory, quantum computational science, quantum communications and philosophy. The concept of entanglement used to build this theory draws the metaphor of entanglement from quantum physics, but is not identical to the theory of entanglement in quantum physics as espoused by scientists (Schrödinger, 1935, in response to Einstein, Podolsky and Rosen). The concept "entanglement" was found in the work of de Santillana (1961) who cites Aristotle (without reference) in discussing the origins of scientific thought as follows:

> Aristotle, a century later, was able to characterise this type of thinking quite properly, if disapprovingly: "Generation for them is neither of many out of one, nor of one out of many, but consists entirely in the concurrence and entanglement of these bodies. In a way these thinkers too are saying that everything that exists is numbers, or evolved from numbers (de Santillana, 1961, p. 147)

in which Aristotle is referring to Democritus early atomistic theory or what we would today call particle physics. The precise nature of the disagreement between Aristotle and Democritus (Chapter 9 Atoms and the Void, sub-heading Theory of Change, pp. 141-160) is not relevant to this theory building.

The use of "entanglement" as a theoretical construct in theory building is an evolution of the concept of entanglement in quantum games and quantum strategies found in the Hanauske et al. (2007) discussion of the choices of scientists with respect to traditional versus open access publishing, noting that these authors did not elaborate on the concept and used the concept to relate specifically to the publishing practices of the scientists concerned. The main influence for the elevation of this idea to the level of core category and theoretical construct was its appositeness for the particular strategic positioning behaviour observed. The use of this concept in Hanauske et al. influenced or confirmed the elevation of the concept to the core category for theory building, as it is considered the most appropriate metaphor to be used to headline the theory, as compared to the other possible concepts that emerged in the dimensions derived

from the data and the analytical categories derived from the dimensions. So, for example, this is not a theory of values and value.

The decision to use "entanglement" as a metaphor is similar to the decision to transplant the term from Bohr's work on quantum mechanics to Barad's (2007) work in philosophy. But the term is not derived from Barad's work, which was only encountered at the end of the theory building process when checking other uses of the concept of entanglement.

Orlikowski (2009) discusses "entanglement in practice", which relates to understanding technological change in organisations, the relationship between computing and information systems and organisations, and what she refers to as the "socio-material entanglement of human and technological activities".
The theory of research entanglement is built through inductive and counter-inductive analysis, grounded in the data from the case study of the university research sub-system in India and the case study of Wits University, with due appreciation to the context of each. Ontologically speaking, the theory describes the coming into being of research activeness (and partly also research intensiveness) to the extent that it can be discerned from the qualitative evidence of an in-depth six-year study of research active universities, some with components of research-intensive activity. Using inductive and counter-inductive reasoning with respect to the data, and transferring the concept of entanglement from the Hanauske et al. (2007) concept of entanglement of scientists in strategical operations, the formulation of the theory of university research entanglement sets out the author's current understanding of such entanglement, arising from the quantum research games played and the multiple collisions and related incidents occurring at universities, which illustrates university research entanglement.

9.5 Reviewing scholarly writing on the analytical categories and dimensions employed

Having established "stable patterns" with respect to the data and its analysis, the next section engages with some of the key literature in discourse on universities and innovation theory. In grounded theory work, it is not required to simply adopt existing meanings of terms and concepts used in the literature. In other words, part of the exercise of theory building is to give different or enhanced meanings to the terms and concepts used. This is relevant for the key analytical categories – actors, institutions, resources, values and value – as pointed to below and advanced in the grounded theory.

This thesis pertains to the research problem of university "positioning" strategy with respect to universities pursuing research activeness and research intensiveness in the 21st century. Positioning strategy falls in the field of strategy, rather than in the field of institutional change, even if strategy and change management are related fields. Nevertheless, many of the analytical categories and dimensions employed are evocative of themes in the considerable literature on higher education institutional change. The analytical categories of actors (sometimes stakeholders), institutions, resources, values and value are present in a wider literature, including in the fields of innovation theory and strategy, business strategy, and others. The crucial issue here is the theory formulation, bringing together the analytical categories and dimensions, rather than addressing each on its own.

There are specific and noticeable reference points between the thesis and the work of Clark. While the type of research problem is similar to Clark's work (mapping the nature and dimensions of the university landscape), the particular research problem of research activeness and the theory formulation is distinctive. Clark shows us the state of the institutions in a particular historical period in the 20th century, while this thesis addresses itself to the emergent strategies in university positioning in the early 21st century, with respect to research

activeness or research intensiveness, the part of the cultural life of the institution that is most clearly connected into the broader innovation system. The dimensions of university positioning set out in this chapter situate actors beyond the organizational saga of loyalty and community, of "basic values", and of other values prominent in the 20th century.

Clark's (1983) concept of adaptive capacity, "the capacity to add and subtract fields of knowledge and related units without disturbing others…the fundamental adaptive mechanism of universities and larger academic systems" is no longer fundamental, as adaptive capacity is much more than adding and subtracting. As found in the case study universities in India and South Africa, adaptive capacity is also about the capacity to foster increasing research activeness through attracting more resources, through absorbing new values systems and through creating new forms of value. Clark (1983) refers to four sets of academic values, namely social justice, competence, liberty and loyalty. The current study presents a wider range of academic values, including open science, research visibility, inner city renewal, based on an early 21st century perspective. However, the thesis is not primarily concerned with understanding each of the dimensions of quantum research games and nuances in these dimensions for their own sake. The thesis is rather concerned with the overarching phenomenon of "positioning" the university with respect to its research activeness or research intensiveness. Notably, in a UNESCO speech entitled "University transformation for the twenty-first century", Clark (1998b, p.4) maintains his earlier views on adaptive universities: "Adaptive universities construct a portfolio of small experimental steps, changing that portfolio from one decade to the next as they learn what works and what does not, and as they sense what new opportunities should be explored". However, his discussion of adaptive capacity (Clark, 1983; 1998b), while noting that universities experience limitations on their capacity to adapt due to funding and regulatory and other restrictions (Clark, 2001), does not grapple with the dimensions of research entanglement that push forward the

emergence of new fields of research endeavour, research-based innovation, new institutional dimensions (for example tech hubs or open access to knowledge), under conditions where the main structures and processes of the university are generally unable to provide a supporting environment and the entanglement process and its outcomes may push forward the university as a whole.

Clark's (1998a) organizational pathways are not easily recognizable in the 21st century university in these particular case studies (i) steering cores are often focused on bureaucratic maintenance, rather than on innovativeness or entrepreneurialism (ii) the developmental periphery of the university is contested terrain and only survives through pushing through adversity (iii) a diversified funding base is possible, but only in a highly competitive environment, requiring long lead times of 15 to 20 years (or longer) (iv) strategic change occurs in the developmental periphery rather than in the academic heartland, where innovation is not a developed culture (v) entrepreneurial culture includes both social and commercial forms.

The theory of university strategic positioning through research entanglement offers an alternative to Olsen's (2005) argument that "institutional success may also carry the seeds of institutional confusion, crisis and change", in that institutional confusion and crisis may be part of a longer cycle of techno-scientific revolution that leads not to success, but to new forms of knowledge production, such as technology hubs or 21st century research institutes. With respect to the arguments against marketization of knowledge (Palfreyman & Tapper, 2009), universities in emerging economies may find marketization desirable as means to encourage greater knowledge production in a scarce resource environment. Furthermore this theory of strategic positioning through research entanglement presents a response to Pinheiro, Geschwind and Aarrevaara's (2014) discussion of nested tensions and interwoven dilemmas with respect to "goals, objectives and strategic interests". These authors conclude that universities and academic freedoms in Nordic countries are limited by "institutionalised norms, values and

academic traditions", by the increase in external forms of control and challenged by the changing social pact between higher education, state and society, thus needing to create "coping strategies" (2014, p.246). They motivate for future research on the nature of the resolution of tensions and dilemmas in relation to the changing social pact. This thesis argues that particular academic actors in the two developing country contexts studied are expressly *not* limited by the tensions and dilemmas they face, but push through these to achieve greater research activeness.

Regrettably, much of the literature on "positioning" in the field of strategy relates to (i) marketing (Urde & Koch, 2014) and (ii) competition (Kalafatis, Tsogas, & Blankson, 2000). Furthermore, no literature could be found on positioning strategies for universities. In this thesis, the interest in positioning lies in how the actors and the institutions (universities) position themselves in their own sector, in relation to how they can be "their best selves", noting the widespread interest to be not only research active, but research intensive, as expressed by universities themselves. While this view also finds expression in public policy, it is the interests of the academics, scientists and universities that is in focus here. This focus on positioning relates to the view derived from Sun Tzu's works (Wing, 1988), namely that the institution is positioned in such a way that it does not have to compete, but that it "wins" because it has positioned itself in such a way that its reputation invites no (limited) competition. In the university sector, while competition is prevalent (for example competition for research funding and research personnel), universities that have a powerful reputation will attract funding and personnel through their "positioning", in addition to direct marketing or direct competition (Mintzberg, Ahlstrand & Lampel, 1998; Wing, 1988).

In summation, the thesis is concerned with "how" research actors and research institutions position themselves for greater research activeness and the transition to research intensiveness within the context of various tensions and dilemmas. So

it is not the existence of the particular tensions and dilemmas that is primary, but rather the approach to resolving these tensions and dilemmas. The theory building is concerned with the ways in which research actors and institutions resolve the thesis versus anti-thesis and successfully find the approach to resolution, to synthesis, or sublation, where the initial thesis versus anti-thesis is replaced, superseded (aufgehoben), a dialectical transition point.

9.6 First explication of the theory of university research entanglement, research activeness and research intensiveness

The theory of university research entanglement, research activeness and research intensiveness is presented, see Box 9.1, as the basis for reflective conversations.

Box 9.1 Theory of university research entanglement, research activeness and research intensiveness

University research entanglement involves participation in quantum research games and multiple collisions and incidents among research actors, research-oriented institutions, research-directed resources, research-oriented values and research value created or deferred. In the research for greater research activeness and intensiveness, research actors and universities create and engage in elaborate games that require both actors and institutions to be constantly playing multiple simultaneous games, each with a significant level of difficulty.

Each game would have multiple research activity components including conducting research while simultaneously scanning the environment for new research opportunities; multiple production components including research design, research project management and decision-making, numerous parallel data gathering programmes, numerous parallel data analysis events, research dissemination and advocacy; multiple resource flow engagements including attracting, securing and building human, financial, technological and electronic communications resources; constant innovation in research or pedagogical approaches including theorising these innovations; functional innovation arising from research and translation into a variety of forms of intellectual property; commercialisation and socialisation of knowledge produced by research; continuous review and debate on the values implicitly or explicitly embedded in the work; objectification of the value derived from the work in relatively specific terms that are not merely jargon or weak compliance statements; multiple publishing components in the form of journal articles and/or patents and or licensed IP and other publications, often with multiple co-authors at the same or different institutions. The research actor in this type of game is engaged in or leading multiple research projects or multiple large-scale research projects which are constantly evolving in complexity; drawing postgraduate (and sometimes undergraduate) students into programmatic research; having held significant local and international funding grants over an extended period; building long-term national and international research linkages; and engaged in extensive peer-reviewed and/or highly cited research publication attracting further research income.

Universities that explicitly, openly and committedly foster such research entanglement have a high probability of transitioning to forms of greater research intensiveness. Universities that explicitly, openly and committedly foster any single form of research entanglement described above have a significant probability of transitioning to greater research activeness with pockets of research intensity. Universities that lean away from explicitly, openly and committedly fostering any form of research entanglement at any level of complexity will fall back against the wider surge towards greater research activeness in the global research community, negatively affecting their capacity to provide a strong pedagogical foundation and to provide the foundations needed for community engagement. All universities can foster some degree of research entanglement as a vital means to their continued operations as universities in the 21st century knowledge-based economy.

9.7 Final phase of theory building: Reflection and re-visioning

The process of reflecting on the theory of university entanglement was conducted by presenting the theory to senior academics including a few of the key informants from the case studies. A number of questions were posed for the purposes of theory testing, though the discussion was conversational rather than interview based. It was not expected that the participants would have a deep understanding of the theory, but the responses could assist in clarifying the ideas presented. These questions and a summary of the responses are presented below. Neither APA reference style nor grounded theory requires explicit referencing of quotations below.

9.7.1 Reflection and theory building I: Respondent, Wits SM1

Question for theory testing: In your experience, are few or many research-actors willing to participate in quantum games?

The respondent alluded to their experience in establishing a new academic entity seeking partnerships with academics from multiple universities. The discipline had specific knowledge streams and the actor encountered contestation from academics in the field with respect to access to resources and ownership of knowledge streams. The actor experienced fragmentation at a disciplinary level. "Owners" of the knowledge streams were not keen to see the creation of an institute that would bring all the streams together. One level of engagement required, therefore, was to break down the boundaries between disciplines, schools and faculties, in order to build the multi-dimensional project.

Academic capacity in the particular field is a scarce resource, hence partnerships within and among universities would be needed. However, the actor was seen to be speaking on behalf of a particular institution, while colleagues at said institution disagreed among themselves on establishment of the institute. The actor was able to navigate the own institutional boundaries and negotiate with senior colleagues in other universities, but needed to persuade these institutional

leaders to break down the boundaries between participating universities. This raised contestation over resources, namely which universities would get the money and which institutions would get the public acknowledgement. In order to address potential contestation over resources and reputation, the actor was required to explain why some partners in the consortium would have greater "benefits" than others.

Similar complexity arose with respect to discussions with funders, who would need to be confident that a number of institutions supported the joint programme, but the actor could not confidently say that the universities would act in support. At each step the actor needed to break down boundaries in order to move to the next step, but there were challenges. "People ask are you establishing a Wits institute or a national institute and if you say a national institute then people say if this is a national institution so why is it at Wits!"

Author's comment: From this theory testing conversation, it would appear that the quantum research game is the reality of the 21st century university. Universities that are going to be successful in the 21st century are those that are going to find a way of breaking boundaries, be they governance, disciplinary, institutional, university and private sector, and other boundaries, different from the 20th century where boundaries were strong, often impermeable.

Question for discussion: What are the characteristics of research-actors in research entanglement and what tools do they need to be successful at this game?
It was argued that functioning at this level needed research-actors who have disciplinary knowledge, who know what is happening outside the discipline in order to make relevant connections, a communicator who can use the language and practice of partnership, can demonstrate the value to the business or other partner institution:

> I am trying to learn those skills, am constantly asking what is the knowledge base that I should build in order to talk to this wide range of actors and institutions in order to access resources, I have to think about what are my (current) views, not my traditional views.

Question for discussion: In your experience, are few or many academics willing to participate in quantum games and research entanglement? Very few.

Question for discussion: To what extent should universities foster research entanglement?

The options appear to be to invest in research actors or research thrusts, though it is unclear which option would have a more successful outcome. Research thrusts could be magnets for resources (students, funding foundations, partners, other), but this is a high-risk strategy because it requires many players and many disciplines to be involved and involves boundary crossing:

> … each of the individuals may not be inclined to play quantum games, but the institution can play quantum games if it has rich teams...

Research entanglement is observed to have unpredictable outcomes, since academic and university endeavour is competitive rather than cooperative and institutions are seen to have become successful because individuals are successful and don't interact with others, which then becomes an obstacle to participation in quantum games. Author's comment: The evidence from this study suggests that highly successful research actors are highly entangled actors, rather than individuals working in a narrow arena.

Final question for theory testing: What are your comments on the resistance to entanglement?

> Actors engaged in simple games are at strategic war with the people engaged in quantum games and their aim is to stop quantum games. Zero sum game is preferred to entanglement, so (these actors are) anti-entanglement. In my view, what seems to be underlying that is the belief that those will succeed at the quantum game will do so at the expense of those who are playing the simple

> game…. we should be proud of our institutions, not contesting about individual universities…so the system can't improve.

9.7.2 Reflection and theory building II: Respondent, Wits-E

A coincidental discussion led to a conversation about research management, and a perspective based on more than a decade of experience in research management. The author found that each new conversation about the theory promotes clarity and perspective.

Presentation of the theory of entanglement leads to the following comments and insights

Presentation: Consider research at a university operating in an emerging knowledge based economy at the beginning of the 21st century (research production is the bounded reality being discussed), where Wits is the case study of the research university. At this university, there are actors (internal and external to the university); there are institutions (internally these are the individual schools, faculties and research entities and externally these are other institutions which may be knowledge clients or knowledge partners); these actors and institutions access and utilise resources (funding, human resources, equipment, time); the actors and the institutions are working to create value (of particular kinds which could be economic value, or social value, or a combination, or simply the value of finding the knowledge); and the actors and institutions (internal and external) access and utilise resources to create value based on their value system (which includes particular principles, beliefs and cultures pertaining to knowledge production). In the games (quantum games) enacted to produce value, the actors must negotiate complexity and navigate boundaries (and also navigate complexity and negotiate boundaries). The actors and institutions, resources, values (we can treat institutional and individually held values as a resource) and processes towards value creation are all entangled together – creating intangible and invisible difficulty or university research entanglement.

Response: The subject advises that he/she has experienced this form of entanglement, has experienced many moments of adversity arising from complexity, but adversity was not experienced as negative. Adversity was often experienced as an opportunity to keep adapting, to continue equipping and skilling oneself in new, previously unforeseen ways, to fight through the experience of entanglement, to use the entanglement as an opportunity (to participate in committees and make submissions on subjects under discussion). The experience of entanglement was an experience of constant transitions, and sometimes of transformative processes, either in the particular project or in self-affirmation.

Entanglement was sometimes also experienced as demotivating: "can be demotivating unless you keep moving, but sometimes you run out of moves". In particular, at Wits Enterprise, the broad objective of translating academic research into commercial or public knowledge has never been fully resourced, so there is a sense of incompleteness, or that entangled processes tend to incompleteness.

The respondent stated that being entangled meant feeling that the processes of transition were very slow when there were particular requirements for them to be faster. The example was quoted of a complex ZAR5million investment decision in research equipment. By the time of purchase, the equipment was obsolete. The obsolete equipment purchased did not meet the requirement for the number of samples to be processed and the large number of samples "crashed" its analytical capacity, meaning that the university could not supply the required service to knowledge clients. The respondent says there are many instances like this, highlighting time and efficiency as resources to decision-making.

Author's comment: This felt sense of slowness of transition could be contested or verified by analysing the pace of transition over the longer term. Through

analysis of the transitions reflected in the studies published in this thesis (India and South Africa), it can be observed that the process of transition has been quite rapid, in that, in the period of a single decade (2004-2014) there has been a transformation at the level of particular research entities (research thrusts and centres), particular processes (IP management, open access scholarly publishing), and at the level of the university as a whole (values, strategy, institutional transformation, research funding flows).

The conversation then moved to the meanings of entanglement and the usefulness of the theory. The author argued that entanglement was a requirement for becoming a research-intensive university and that the role of universities therefore is to create the entanglement, but not to solve it, not to provide all the answers or circumstances or resources for the resolution of the entanglement. It was the role of the institution and of its many actors to create the playing field of entanglement, so that actors and institutions could take up the challenges associated with resolving them. With greater entanglement of actors and institutions, there would be greater movement towards a more advanced state of existence (of project, or institution, or research actor). As the conversation continued, the respondent asked: "How do you measure or analyse the success of entanglement?" The response from the researcher was: The institution must research itself in order to understand its own transition and to understand the benefits gained from being a highly entangled institution. It must convey the beneficial notion of the entangled university to its actors, in ways that challenge the "safeness" of the traditional institution and its sub-cultures and mores.

A new direction arose in the conversation: One of the contributing elements to entanglement was mis-explanations – for example the mis-explanation of the policy on full cost recovery for research conducted for external clients. This comment suggested that research actors must leave room for knowing that mis-

explanations or mis-interpretations may constantly occur and create the opportunity for re-explanations, for example the meaning of full cost recovery when engaging in contract research. Different research actors interpret and respond to the requirement for full cost recovery of research differently, requiring regular re-explanation of the cost recovery policy.

9.7.3 Reflection and theory building III: Respondent Wits-eLSI

The eLSI respondent comments on the notion of entanglement as being enmeshed, in a constructive sense:

> If you want a bureaucracy you streamline actions, but that leads to efficiency not innovation, whereas if you have many different agencies and people to create this entanglement (it) allows the right people to connect to each other which leads to innovation, for example where Wits infrastructure and academics and some outside groups are finding a way to mesh their individual interests.

Question for discussion: Whom does entanglement help and how does it help? The respondent argues that academics are always looking to understand what they do from a theoretical perspective, so a theory would be useful.

9.7.4 Reflection and theory building IV: Respondent Wits-SM3

The key informant argued that the relevance of the theory of university research entanglement would depend on where a research actor sits in a university and referred to how the perspective of the academic changes as they transition from head of school to Dean to DVC, how the lens they use to view the university changes from representing the academics in the faculty to representing the perspective of the centre. The positioning of the research actor is also important, as it is possible that a highly cited scientist is driven by particular academic values anyway, but doesn't want to be entangled in the business of the entire organisation. Such a research actor may tend to be less interested in the collective endeavour, but pursues excellence from isolation – interested in their discipline, their research, and top students in their sector.

The respondent commented that establishment of universities as knowledge generation enterprises was historically connected with the creation of knowledge hierarchies and disciplines which push for isolation, and that the desire for multi-disciplinarity is a new feature, and there was still resistance. The respondent referred to the push for a move from qualification type to learning type programmes a decade previously, when academics did not want disciplines to be dismantled and saw the broader qualification as an attack on the existing knowledge hierarchies. The respondent argued that there was still a strong knowledge hierarchy and strong disciplinary identities that seek to be preserved, where research actors represent an anti-entanglement position.

9.7.5 Reflection and theory building V: Respondent, Indian higher education

The response to the theory of entanglement immediately understands that the five domains are entangled – actors, institutions, resources, values and value:

> …thinking about these as intersecting Venn Diagrams with overlaps and complexities coming from them, first reaction would tend to agree and would want to agree – to me it makes quite a lot of intuitive sense – a good reflection of the experience I have.

The five forces are all seen to come from the same social system, but to have varying lifespans. For example, a research actor has a finite timeframe, an active research life of 35-45 years. Whereas values may show only an incremental change in that same period, yet show significant change over a longer period of time. In the same way, the contemporary leadership of research institutions would have their own short-term views within short timeframes, but the institution may not change its values:

> …even if four or five leaders in succession wanted to…The values of individuals could be instrumental values while the values of the institution could be terminal values, or vice versa. Instrumental values may fluctuate with actors, but terminal values reside with institutions.
>
> Any of the five elements may manifest in each of the other remaining elements of the theory of entanglement. Universities need individuals, the institution and the

> wider ecosystem to excel and accommodate diversity and if any of the five elements takes a beating then entanglement takes a beating. This phenomenon is observable in research – people always wanting to work by themselves, or always wanting to do collaborative research. Whether research actors collaborate or don't collaborate, both approaches can make universities open and excellent.

The respondent states further:

> …(I have) faced those challenges, faced up to them, broke through those challenges, theorising some of those challenges… I relish entanglement, but society needs both kinds – entanglement and anti-entanglement. I have been trying to do the unconventional irrespective of what pressure it puts on me, it makes my understanding wider and I understand ambiguity better, but my attention span becomes shorter, whereas someone who shies away from this may have a depth of looking at a particular problem, whereas someone else finds it boring to look at one issue. The super-specialist and the entangled leader both produce innovation and shift institutions. The risk is that leaders with high degrees of entanglement may not have a sense of obsolescence but the institution (needs to) metamorphose, whereas the second person may create a specialist organisation and the risk is that because of a technology or environmental change the institution may die.

9.8 Re-visioning the theory of university entanglement and research intensiveness

The theory testing conversations confirmed the initial expression of theory and added several perspectives, including the observation of the position of leaning away from entanglement or "anti-entanglement". Furthermore, the theory testing conversations revealed the insight that anti-entanglement can be either an important stabilising force for universities, or alternatively anti-entanglement can generate an undesirable culture against entanglement. It would be necessary to continue the investigation into this theory of entanglement over a longer period, through a larger number of case studies, to understand its explanatory value with respect to universities inventing new capabilities to foster research activeness and research intensiveness in formative knowledge economies, a basis for future research and future researchers.

9.9 Chapter summation

This chapter has two important aspects (i) it provides the synthesis of the dimensions of actor and institutional behaviour with respect to the university research sub-system, organised in five analytical categories, which enables theorisation of positioning strategy for heightened research productivity; (ii) it collects together the qualitative dimensions or types of metrics that would enable the study of the university research sub-system with respect to the effective positioning of research entities for greater research activeness and research intensiveness; and (iii) it offers a foundation for contemplating how these analytical categories and dimensions may be used to explore research and innovation practices in research entities including technology hubs producing software innovation and knowledge hubs producing social value, both inside and outside the university context. It is noted here that effective positioning strategy, which fosters the success of research and innovation projects, and positions the entity in terms of its reputation for research success, is necessary for scaling up university-based research, particularly with respect to research entities.

This study has generated a set of more than 65 qualitative metrics, clustered in five analytical categories. These metrics focus on the idea of research, in an innovation studies context. The purpose of this study will be to focus more explicitly on innovation dimensions, with attention to tech hubs, an opportunity to expand the range of the qualitative metrics, to add quantitative metrics, and then to adjust the metrics to a smaller more manageable group of possibly the most important 25 – 30 metrics, that could be fashioned into an innovation strategy approach specifically for emerging tech hubs. Regulatory issues did not emerge as a cluster of data for these studies.

Chapter 10 Conclusions and application of theory: Positioning strategy for research activeness and intensiveness

This concluding chapter comments on the originality of the research and significance of the theory generated, on methodology, on the contextual setting for the theory, on the meaning of the theory for strategic positioning. The thesis examined endogenous factors in research activeness and intensiveness, rather than exogenous factors common in the debates on universities in the knowledge economy (globalisation and internationalisation, marketisation, policy and regulatory conditions in the higher education landscape).

In seeing into the complex university research sub-system, the thesis presented five case studies (an exploratory case of research active universities in India; a case of the evolution of an urban digital tech hub; a case of the evolution of a rural knowledge facility into a 21st century research institute; a case of the evolution of an intellectual property and tech transfer management capacity; a case of the evolution of a scholarly publishing paradigm). Analysis of the case study data led to a progressive realization of some of the key facets in positioning for research activeness and shifting to research intensiveness. Effective positioning leads to enhanced research production, new fields of research, new types of research entities, increased research visibility, more valuable knowledge, in other words, greater research activeness and research intensiveness.

The research process required rephrasing the main research question to: How do university research sub-systems position universities to push through conditions of adversity to realise research activeness and intensiveness? The data gathered for this study enabled a theoretical response to the question. It also shed light on the ways in which scientist-researchers increase their knowledge production in a knowledge-based economy. An appreciation of and further responses to this question may contribute to the adoption of practices that lean towards increasing research activeness. This research elucidates specific practices by which a few

research-active universities in two developing countries are positioning themselves in the context of a large-scale socio-economic transition.

New theoretical insights, such as that proposed here, contribute to understanding university change – there is no single theory that explains this complex field. Using Cryer's (2006) guidelines, originality in this work can be found in:

(i) the attempt to work across the fields of innovation studies and higher education studies, a cross-field or multi-dimensional perspective that remains relatively unexplored, notably the application of innovation theory to the university research sub-system

(ii) utilization of grounded theory to search for new insights on the subject of university research activeness and intensiveness, other than that which is already theorized

(iii) exploring the unanticipated – the strategy of university positioning – where the main route is being extensively explored (universities in the knowledge economy), and research activeness and research intensiveness is a less explored sidetrack, leads to exploring the sidetrack

(iv) collecting and presenting the data required: for charting the evolution of a digital technology hub in a developing country, for charting the evolution of a 21st century research institute in a developing country, for presenting a limited mapping of the university research sub-system in India, for analyzing the research active behavior of scientist-researchers

(v) the research experience, where the early idea of researching universities in the knowledge economy was too broad and superficial, requiring the researcher to progressively work their way to greater levels of depth in charting the research problem, research question and research design to find the less explored side-track; and

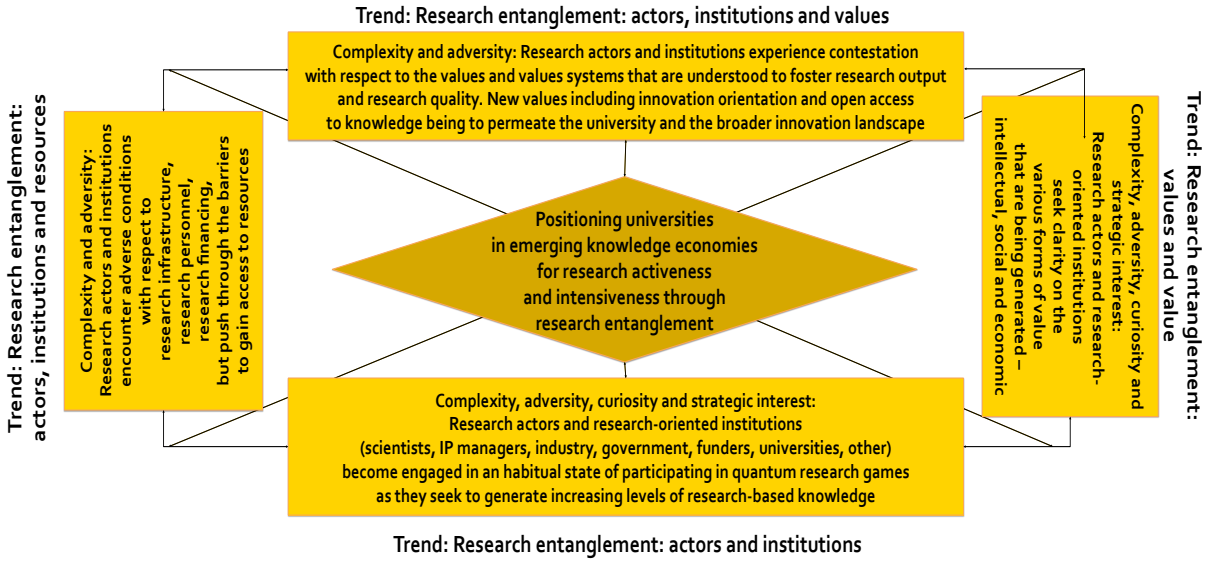
(vi) originality as potentially publishable, an article on new forms of value was published, plans for future publication include adapting the chapters

on the evolution of the digital technology hub and the 21st century research institute, as well as working on a publishable version of the theory of research entanglement.

10.1 Elaboration of the theory of positioning universities through research entanglement

The process of theory building and theory testing conducted in this thesis leads to the final elaboration of the generally applicable theory in this section. The theory of positioning universities for research activeness and research intensiveness is a theory that gives substance to the broad notions of complexity and adversity in building university research. A way of thinking about the theory of positioning universities through research entanglement is represented in Figure 10.1 below.

Figure 10.1 Diagrammatic representation of the theory of positioning universities for research activeness/intensiveness through research entanglement



The theory claims research entanglement is a trope or metaphor for how university-based scientist-researchers engage in research activeness and

transition towards research intensiveness, influencing the positioning of universities in emerging knowledge economies. There are four main trends arising from particular associations among the five elements of entanglement, namely research actors, research-oriented institutions, research resources, research-oriented values and research value. A balancing act is required between leaning towards and leaning away from research entanglement, in order to sustain the stability of the long term endeavour to increase the volume and quality of research output. However, the absence or discouragement of research entanglement at universities limits the opportunities for increasing research activeness. These theoretical insights will be of interest and significance to universities in emerging knowledge economies who aim to increase their research and knowledge production, without specific reference to people, time or place (Glaser, 2002).

10.1.1 Trend: Research entanglement: actors and institutions

Research actors, universities and partner research institutions experience high levels of complexity and adversity in attempting pioneering research that breaks existing knowledge boundaries, with the objective of increasing their individual and institutional research activeness or research intensiveness. Complexity and adversity is often counterbalanced by curiosity and strategic interest. In order to push through this adversity, research actors and institutions enter into a habitual state of research entanglement, as they engage in research processes to produce, publish, socialise and commercialise knowledge. The quantum research games that arise in these processes require actors and institutions to embrace research entanglement, in order to achieve an increase in research intensity.

10.1.2 Trend: Research entanglement: actors, institutions and resources

Research actors, universities and partner research institutions engage in competition for scarce research resources including research personnel, research equipment and infrastructure and research financing. The competition for these

resources is a long-term endeavour, where actors and institutions increase their competitiveness for resources and attractiveness to funders through long-term engagement and willingness to embrace entanglement in complex processes and mechanisms to unlock access to resources.

10.1.3 Trend: Research entanglement: actors, institutions and values

The entanglement of research actors and universities in the endeavours to increase research intensity exposes the contestation between historical values systems of universities (emphasis on ideas such as excellence) and emerging values systems (emphasis on ideas such as innovation), as well as between values systems of universities and values systems of partner research institutions. In these circumstances, actors re-interpret values in ways that advance their research practice, while universities and partner research institutions are reluctant to leave the known terrain of values. The contestation over values systems could be strong or weak at various conjunctures, but the re-interpretation of values or adoption of new values is important to pushing through the adverse conditions of research production to achieving breakthroughs in knowledge.

10.1.4 Trend: Research entanglement: values and value

Research actors and universities seek to better understand the advantages and disadvantages pertaining to how particular sets of values will lead to particular forms of value, thereby displaying curiosity and strategic interest. For example how research excellence may enhance the international academic reputation of the university, or how innovativeness may enhance the international academic reputation of the university; as well as how research excellence may promote deriving social or economic value from the investment of public and private research funds, or how innovativeness may promote deriving social or economic value from the investment of research funds. Research actors and universities are influenced in their thinking and conduct by the interpretations of the relationship

between values and value held by partner research institutions. In striving to convert knowledge to value, research actors and universities may experience complexity and adversity.

10.1.5 Positioning: Leaning towards research entanglement

Research actors and the university embrace the adversity and complexity that is a part of the habitual state of research entanglement, with the understanding that encouraging research entanglement presents a potential advantage for the university in promoting scientific knowledge production. The more universities and research actors lean towards research entanglement, the greater the progress towards research activeness or intensiveness.

10.1.6 Positioning: Leaning away from research entanglement

Research actors and the university hold the view that leaning away from research entanglement at certain times, or by certain actors is important to sustain the stability of the institution and the long term research endeavour, whether this is a lesser or greater group of actors.

10.1.7 Theory of the whole

The sections above present the theory of the whole. The creative elements of the theory of research entanglement are that it may foster the necessary individual and institutional capacities and strengths for high levels of research activeness and research intensiveness. The transforming elements of the theory of entanglement are that it understands chaos as highly productive and transformative to institutional capacity for research. The restrictive elements of the theory are that it observes that actors and institutions encounter continuous high levels of adversity, hence universities that have no history of research activeness may be disinclined to adopt this theoretical or strategic positioning stance.

10.2 Significance of the theory of positioning universities for greater research activeness through research entanglement

Globally universities have, over the last century, been undergoing particular forms of change, as they consider ways to utilise their knowledge capital and capabilities. Thus, they have become increasingly research oriented, finding new ways to earn income and reduce their level of dependency on public funding. Forces of change in the 20th century included the demand for high-technology research to foster late industrial societies, leading to entrepreneurial science (Etzkowitz, 2002). The rise of services economies towards the end of the 20th century and the 21st century economics of global change ushered in an era of services-oriented science (Chesbrough & Spohrer, 2006), including demand for research on climate change, water scarcity, global migration and population issues, hunger and poverty, war and welfare (Sachs, 2008). Other drivers of higher education change include the rise of the information economy (Melody, 2002) creating opportunities for web-based scholarly publishing and dissemination of knowledge, and a shift from copyright licensing of university publications to open access licensing fostered by the open access movement of the last two decades (Gray, 2010).

Forces of change internal to universities include the interest of scientists and inventors in solving the problems of the day. These and other factors relating to the geographic and socio-economic context, national policies and institutional dynamics, have contributed to increasing research intensity and increasing the value of university research to various knowledge communities (Abrahams & FitzGerald, 2012).

In the second decade of the 21st century, it is becoming apparent that many forms of knowledge economy are evident around the world (Abrahams & Pogue, 2012) and that knowledge economies may emerge in "small, less favoured regions" of the world. The attribution "knowledge economy" may be interpreted as the

application of research-based knowledge to any social or economic demand for such knowledge, whether in highly industrialised and services-based economies, or in marginalised economies with particular demand for social-scientific knowledge investment. Economic development in each of these environments can be understood to require social-scientific knowledge investment, not only development finance or infrastructure investment. University research activity is one of the important contributing branches to such knowledge investment. However, university research is a difficult endeavour, rendered complex by limited capacity to compete against the historically embedded constraints of policy, funding, governance and management. In this environment, adaptability of research actors, the university as research institution, resources and values are key factors in producing research for academic or socio-economic value.

In which ways does the theory of positioning universities through research entanglement aid our understanding of universities? In this thesis, research entanglement is considered to be an advanced form of adaptive decadal change and universities can use entanglement to foster progressive realisation of their ambitious research aims. Let us linger for a moment on the notion of decadal change. It is often difficult to observe institutional change or programmatic change or socio-economic value over the short to medium term (1 to 3 years). It is more usual for the characteristics of change and the factors fostering such change to be observable over the long term (5 to 10 years) or over the very long term (10 to 30 years). For the purposes of understanding university change in the case study institution, it was deemed appropriate to study adaptive decadal change over a single decade 2003 to 2013, in order to observe particular characteristics, factors and the underlying reasons associated with these characteristics and factors. In retrospect, the decadal view made it possible to unearth a variety of features of the evolution of research at universities that would have been difficult to see over a shorter timeframe. While the main data collection took place between late 2008 and 2013, a limited historical review back to 2003 gave a better

sense of the changed state of the factors, namely the actors, the institution, the resources, the values and value. This ten-year review also enabled the author to understand the theory of entanglement of universities in research production as a phenomenon that is pertinent to the formative stage of knowledge economies, rather than to the latter stages of industrial economies. It may be that there are many phenomena that may be referred to as entanglement, but in the particular case of universities entangled in research production, this is considered by the author to be a peculiarity of early stage knowledge economy formation.

In emerging knowledge economies in less favoured regions, universities will have to be innovative in particular ways. Higher education is situated in an important relationship to innovation and to national innovation systems (where these have already formed) therefore it needs to focus on producing novelty. The significance of this theory applies both to institutional change and to the role of actors, institutions, resources and values systems in the evolution of scientific knowledge. One aspect of the importance of the theory is its predictive value, the extent to which it can be rendered a law – under all conditions x, items defined as the particular variables will produce this kind of consequence. Based on this study it is argued that, under all conditions where universities are aiming to position themselves for greater research activeness or research intensiveness producing novelty in formative knowledge economies (*conditions x*), items defined as entanglement of research actors, research-oriented institutions, research-oriented resources, research values systems and the value thereby created (*variables*) will foster this kind of positioning.

In this environment, university research actors, university managers and governing bodies, higher education policy-makers and regulators, academic research funding bodies, industry partners, non-governmental development institutions associated with universities, and others engaged or interested in fostering greater academic research activeness and intensiveness should be

encouraged by the great challenge of 21st century knowledge production. These interested parties should welcome entanglement and feed off it as a nurturing force for research production, without which the indigenous/endogenous growth of scientific and social research will not mature. Indeed, the theory explains the entanglement experienced by these actors and their lived experience of participating in quantum research games. In order to pursue advanced decadal change, observing or encouraging entanglement of universities in research production is a mission to be fostered, side by side with maintaining institutional stability. Stability without entanglement leads to stasis.

The counter to this theory could be that this is all common sense. However, if we review university strategy or higher education policy, this is not apparent. The focus of strategy and public policy is on highly generalised, often vague goals and ambitions are set, with little or no reflection on the positioning of universities that will enable these goals. The contribution of this theory to social science is its insight into the trends, tropes and positioning of universities in formative knowledge economies, insights into individual and institutional behaviours and into the kind of research entanglements that present the biggest challenge.

10.3 Methodological and evolutionary process of the study of positioning universities in emerging knowledge economies

The scope of this study evolved towards understanding the research active university and building research activeness and intensiveness at universities, as a way of understanding the university in the 21st century knowledge economy. The aim evolved towards understanding why and how universities are able to foster research activeness or intensiveness. Hence the boundaries for the study relate to the production and dissemination of university-based research and the role of university actors and institutions as either bound by historical institutional research culture or as co-creating future institutional research culture.

Grounded theory has been illustrated to be a valuable methodological stance, enabling in-depth investigation and theory building. A grounded theory approach requires the researcher to build the understanding of the problem from the emerging data and to build the theory through an iterative process of data collection, analysis and theory construction. Thus, early parts of this theory pertaining to values and value were formulated in the period 2008, following the exploratory research in India and an initial search for subjects at the case study institution. This early exploration led to a clear definition of the problem as a problem of understanding how universities achieve research activeness or intensiveness. Over the period 2008 to 2013, the theory building evolved through continuous data collection, data analysis and theorising specific facets of the final theory. This exploration led to the concepts pertaining to positioning universities towards research activeness through research entanglement, from which the final theory building developed in the period 2013 to 2014. Some of this progressive theorisation generated two published journal articles (on research visibility and open access publishing [Abrahams, Burke & Mouton, 2010]; and on values and value in higher education [Abrahams & FitzGerald, 2012]), one book chapter (on IP management and open access publishing [Ncube, Abrahams & Akinsanmi, 2013]) and a commissioned research report (on the revitalisation of higher education in Southern Africa [Abrahams & Akinsanmi, 2012]). During the research and publishing processes, it was possible to explore some of the key themes emerging from the data analysis, and some of the theoretical ideas.

As Feyerabend states in his critique of the conventional wisdom regarding scientific method '…theories become clear and 'reasonable' only *after* incoherent parts of them have been used for a long time. Such unreasonable, nonsensical, unmethodical foreplay thus turns out to be an unavoidable precondition of clarity and of empirical success' (1993: p.18). Researchers must be encouraged to explore the uncharted terrain of an emerging knowledge economy in order to gradually distinguish its contours, craters and plateaus. This study sketches a

new aspect of the theoretical terrain with respect to universities and higher education sectors in formative knowledge economies, as it discusses trends in institutional change, while much of the extant literature on universities in the knowledge economy discusses particular characteristics of universities such as entrepreneurial science or increases/decreases in scientific production.

10.4 Context of application of the theory of university research entanglement

This section briefly discusses three contexts in which the theory of positioning universities for research intensiveness through entanglement would be applicable.

10.4.1 Context of South African universities

South Africa has 23[24] universities, of which nine produced between 1.0 and 2.0 total research outputs per permanent academic staff member per year (Masters and Doctoral graduates and accredited research publications), while 14 produced less than 1.0 total research outputs per academic staff member per year between 2000 and 2011 (FFC, 2013, p.279). All universities except one regularly produce doctoral graduates and all universities produce research publications. All universities compete for international and local research funding, both public funding and industry funding, with the greatest level of competition offered by the five universities with the highest research intensity.

The highest enrolments are in science and technology, then in business and management, then in education, then in humanities, and the highest publication rate is in sciences and humanities (CHET, 2013a). Cloete, Maassen and Moja (2013) claim that the introduction of the 2005 research output oriented funding framework by the Department of Higher Education and Training strongly influenced the increase in the annual publication output from around 5,000 publication units in 1996 to around 10,000 publication units in 2010, though only

[24] Two new universities were established in 2013 but are not yet engaged in postgraduate programmes or research publication

approximately 6,000 of the 16,000-plus academic staff had PhDs in 2010 compared to less than 5,000 of the then 13,000-plus academic staff in 1996. Furthermore, research output funding grew to ZAR2.2bn in 2010 (9.2% of total funding envelope) and research development funding grew to ZAR 0.2bn (0.7% of total funding envelope for higher education) (Cloete, Maassen & Moja, 2013).

Higher education research financing operates under major constraints. In this environment, a number of scenarios arise (i) well resourced universities continue to dominate in the attraction of research funding; (ii) both well resourced and poorly resourced universities struggle to attract significant additional funding because university management is already operating at the extremes of capacity to raise funding; (iii) raising research funding detracts from the capacity to raise funding for the degree and building programmes of universities; (iv) the failure to attract continued research funding over the medium to long term leads to the decline of university research with negative effects for the broader innovation system. These difficult funding and resourcing choices are only some of the contextual factors impinging upon the entanglement of universities and their capacity to become research intensive or not.

Significant change has occurred in the university sector with respect to increasing research activeness for all universities and increasing research intensiveness for the top research producers over the first and second decades of the 21st century. For example, the Vaal University of Technology (VUT), which is relatively junior in terms of research capacity, adopts a "triad" research-technology invention-technology innovation philosophy and hosts a Technology Transfer and Innovation Directorate (engineering manufacturing, enterprise development, iron and steel innovation, materials processing technology), which earned income of approximately ZAR46milion in 2011 (VUT, 2012). VUT hosts three research centres (sustainable livelihoods, applied electronics, chemical and biotechnology) and three research focus areas or platforms (environmental

pollution, plant molecular genetics, materials technology). The universities of Cape Town, Pretoria and Stellenbosch have policies on open access scholarly publishing and the ASSAf Internet-based open access publishing platform, Scielo South Africa, hosts some of the top scholarly journals in South Africa.

Given the complexities outlined above with respect to postgraduate throughput, research production and publication, and research financing constraints, a theory that discusses the complexity of the university research landscape and the entanglement that arises therefrom can provide some insight into the entangled experiences of research actors and institutions and render these experiences normative rather than marginal.

10.4.2 Context of universities on the African continent

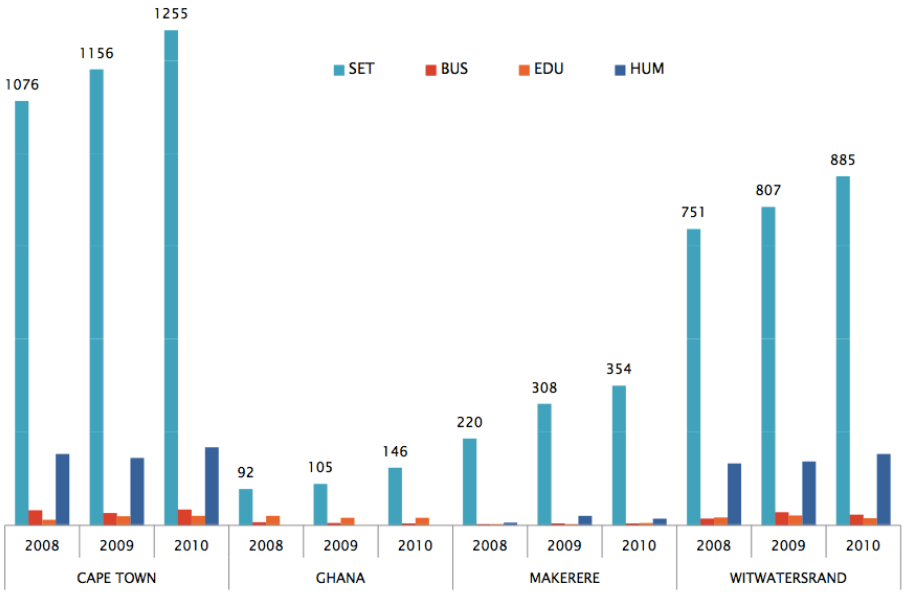
Universities on the African continent have a long-term interest in growing their research capabilities and the research effort. The African Union's Plan of Action for Higher Education Renewal (African Union, 2006, section 2.4 paragraph 42) proposes:

> Complete revitalisation of higher education in Africa, with the emergence of strong and vibrant institutions profoundly engaged in fundamental and development-oriented research, teaching, community outreach and enrichment services to the lower levels of education; function(ing) in an environment of academic freedom and institutional autonomy, within an overall framework of public accountability.

While the comparative strength of universities on the African continent differs across countries and across economic sub-regions of the continent, revitalisation of continental higher education requires African research, continental knowledge production about the continent by researchers living on the continent for dissemination on the continent and further abroad. A study by CHET (2013b), comparing research publication in four African universities (UCT, University of

Ghana, Makerere University of Uganda, University of the Witwatersrand) offers a perspective on the size and shape of research production, see Figure 10.2 below.

Figure 10.2 Research production in four African countries



Source: *CHET, 2013b*

The publication data on which this graph is based are extracted from the Web of Science for the period 2008-2010, thus including all research publications appearing in the citation indexes for arts and humanities, social science, and science-expanded (CHET, 2013b). The graph illustrates that the relative size of publication (numbers of articles) differs significantly across the four universities, but the shape of publication is similar, namely the highest publication rate is in SET, while humanities features second highest at UCT, Makerere and Wits, indicating that science and technology research is in the greatest supply and possibly therefore in the greatest demand. All four universities show a significant increase in the number of publications per annum from 2008 to 2010, indicating that all universities are seized with increasing their research publication output.

In discussing the "dynamics of intellectual production in African universities" in the 21st century, Olukoshi and Zeleza (2004, p.616) pose a series of questions that are illustrative of the context within which the theory of university entanglement can be used to explore and advance research activeness and research intensiveness:

> …how has the mathematization of the 'queen' of the social sciences, Economics, and the quantification of Political Science been received by African academics in those disciplines; and how are the new high-tech interdisciplinary frontiers from information technology and biotechnology to nanotechnology and environmental technology faring in African universities? What are the interface and interlinks between 'indigenous' and 'international' knowledges? How are African universities responding to the trans-disciplinary modes of study and research deemed necessary to deal with complex and interrelated global challenges and exploit the possibilities offered by networking, which are making, some argue, the disciplinary organization of universities obsolete? What is the state of the infrastructure of knowledge production in various parts of Africa – research and publishing – and how do they relate to the structures of scholarly authority and legitimation and in the reputational stakes of career promotion and recognition?...there is much to be gained in analyzing the intellectual trends in African universities and comparing them to…the trends in other regions…

This rather lengthy final quotation raises two important points (i) African universities will confront the same challenges as universities in emerging economies like South Africa and India in their endeavours to increase research activeness and transition into new disciplinary modes of research and (ii) the state of research and publishing requires research that can shed light on the paths that will need to be pioneered in universities across the continent.

10.4.3 Context of universities in other emerging knowledge economies such as India

Universities on the South American and Asian continents, indeed universities in middle- or low-income economic regions, may look at leading research universities in South Africa or India and may believe that they cannot achieve what these universities have achieved because they do not have the history or academic resources or scientific progression or financial resources or any other

particular conditions that have made Wits or Visva Bharati the institutions that they have become. However, the theory of universities entangled in research production suggests that many more universities in emerging knowledge economies can undertake the transition to research activeness and research intensiveness, difficult as this may be.

10.5 Conclusion and further research: Trends, tropes and strategic positioning of universities with respect to research

The trends discussed in this thesis relate to universities operating at the frontiers of emerging knowledge economies, engaged in quantum research games, rather than in simple or complex games. The degree of complexity of performing research and attracting research funding, attracting and producing excellence in postgraduate and scholarly research, the degree of uncertainty in performance with respect to research outcomes and inventions, renders the university game a quantum game, because any individual research actor is simultaneously participating in difficult, high-risk games with many other actors and institutions, accessing a complex pool of resources, adopting an expanded values system to achieve multiple forms of personal and socio-economic value.

Participation in such quantum games creates entanglement of universities and their research actors in striving to achieve greater research activeness or greater research intensiveness. In terms of the broad trend of research entanglement, research actors, universities and partner institutions will either lean towards or lean away from entanglement as a preferred mode of existence at the university. Such individual or institutional behaviour of leaning away from or leaning towards entanglement are the behavioural tropes of key actors.

This theory argues that positioning universities for greater research activeness and greater research intensiveness requires both tropes (or techniques), leaning towards entanglement and leaning away from entanglement. Leaning towards

entanglement pushes the entire operation, possibly the entire system into a higher gear of research activity, while leaning away from entanglement stabilises the organisation of the university. However, in the 21st century knowledge economy, the leaning towards entanglement trope must be strengthened significantly or universities will simply remain stable but will not prosper or innovate in research terms. The conclusion presented here does not argue that universities should formulate positioning strategy for research activeness and research intensiveness. They may choose to do that, but it is not required. Rather this work has attempted to make explicit the nature of such positioning as scientist-researchers engage in this positioning, as it may be of interest to scientist-researchers seeking to enhance research activeness and to researcher managers to know what other scientists "are doing" and to validate the practices of those who are already so engaged, in other words "strategy as analytical process" (Mintzberg, Ahlstrand & Lampel, 1998). These engagements may or may not break universities and their research sub-systems out of their path dependencies – this was not investigated in this study and no claims are made in this regard.

A number of authors (Barad, 2007; Bub, 2013; Hanauske *et al*, 2007) discuss quantum games and their application in various environments including the university, but these authors have not contemplated quantum games as a wide-scale phenomenon in universities engaged in positioning towards knowledge intensity and research intensiveness.

It is intended that this theory of university research entanglement should encourage further research and formulation of a greater understanding of the actions, processes and interactions leading to greater research activeness and intensiveness. Future research could examine the extent to which this theory of university entanglement in research is observable in inter-global research competition (how do universities of the global South play the quantum games

with respect to research actors, institutional adaptive change, strategy design [resources and values], and value derived from research outputs). Further research could also examine inter-university, intra-university and intra-faculty competition (funding, perceptions of power, visibility, accessibility, productivity, generational quantum gaming).

Another aspect of the theory that would be of interest for future research is a study of the positioning of digital tech hubs, of which there are approximately 90 on the African continent, including in Ethiopia, Kenya and Nigeria, where scaling up may require innovation entanglement. Innovators and tech hubs often consider the goals of their endeavours, but not equally often the innovation strategies required to achieve the goals. For many newly established tech entities or tech environments, strategy happens on the fly, with limited attention to goal-oriented strategies to maximise results. Some tech hubs may follow linear strategies and success may be hit or miss. Other tech hubs may crash and burn. A few tech hubs become really successful and really powerful. As researchers, we should ask why some tech hubs are successful and others not!

This concluding chapter argues that positioning universities for research activeness or research intensiveness requires active research entanglement of the actors and institutions in the games of adversity that are played out with respect to access to and competition for research resources; with respect to contestation over research-oriented values; and with respect to the possible trade-offs among academic value, social or economic value created as outcomes of research. It argues that research entanglement advantages those universities who lean towards entanglement in that they become adept at generating scientific knowledge for the 21st century.

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Appendix A PhD research: Information sheet and semi-structured interview guide – South Africa

Title: Universities in the knowledge economy in South Africa and India: Trends, tropes, positioning

Name: Lucienne (Luci) Abrahams, Student No. xxxxxxxx, mobile: xxxxxxxxxx

Supervisor: Dr Mike Muller, Graduate School of Public & Development Management

Request: You are invited to participate in this study by responding to a limited number of questions for the purposes of PhD research. You have been selected as a key informant because of your institutional knowledge of Wits University. The interviewer would like to conduct a one-on-one interview, which should take a maximum of one hour. Please read the following outline in order to consider your participation. An informed consent form is attached for your signature.

Overview of the study: The subject "universities in the knowledge economy" is a growing area of interest to scholars and practitioners in African and Asian societies. For the purposes of this research, the concept "knowledge economy" refers to an environment in which the rate of production of new knowledge (data, ideas, theories, knowledge claims, inventions, prototypes, patents, licences, knowledge for social development, applications of indigenous knowledge, other) has increased exponentially, speeded up by the relative ease of accessibility to this knowledge through extended global institutional networks and the Internet, as well as through increases in R&D funding. *Innovation*, in institutions and institutional practices, is the key word.

The purpose of the research is to examine the trends occurring at research active universities in South Africa and India, the nature of and reasons for these shifts; and based on the findings, to elucidate a theory of the positioning of research-based South African universities in the emerging knowledge-based economy. The research pursues a case study methodology, using grounded theory techniques for coding responses and for theory formulation. This is a qualitative study, where the interviewer is interested in the ideas and reflections of the respondents with respect to changes and developments in the university, particularly in the research environment, as reflected in the guiding questions below. The researcher is not interested in any quantitative data.

Deciding to participate: Participation is entirely voluntary. You are free to withdraw at any stage without giving a reason. There are no risks to participation. The study may have several beneficial outcomes, as the researcher publishes and contributes to the

public discourse on universities, in South Africa and internationally. A few quotations from selected interviews will be included in the final report. The examined report will be published on Wits open access repository WIReDSpace.

Anonymity and confidentiality: Any limited personal information collected about you will be kept confidential. Names will not be listed in the published report, unless specifically agreed to. Please note that it *may* be possible to identify the interviewee where reference is made to a particular area of research or research administration, but this will be implicit rather than explicit in the report. The anonymised data generated in the course of the research will be kept securely in paper or electronic format for a period of five years after completion of the study.

University of the Witwatersrand case study

Designation and institutional component of Key Informant:

Date and Time of Interview:

Please note that these are guiding questions. The researcher is interested in noting and understanding any changing trends that reflect on Wits as a research active university.

Section 1 General Background

Q1 Please share your story of the university in the past ten years – the transitions, successes and failures from a "knowledge economy" perspective.

Section 2 Perspective on the University (internal focus)

Q2 What are the areas of research excellence in your school/faculty?

Q3 What are the reasons for this achievement?

Section 3 Perspectives on Research @ Wits University

Q4 How has the research paradigm and practice shifted in the last decade? Give examples, explaining any challenges.

Q5 How is continuous innovation in research promoted?

Q6 How well does X (school/centre/institute) mobilise broad knowledge networks to support its research and innovation activities?

Q7 How well does X use ICT services to enhance research?

Q8 How well does X mobilise government and private finance to support its research and innovation activities?

Section 4 Perspective on innovations in teaching and learning

Q9 What are the successful models of teaching and learning (inter-disciplinary or multidisciplinary work, and knowledge partnerships)?

Q10 What changes or advances do these new models bring for postgraduate students and academics?

Q11 How well does X use ICT services to enhance teaching and learning?

Section 5 Perspective on talent, race and gender

Q12 What levers does X use to attract and foster talented postgraduate students, academics and scientists?

Q13 What measures does X employ to increase the participation of men and women in leadership and decision-making in the University, and at the level of the Professoriate?

Section 6 Perspective on the large research-based university in the broader 'knowledge economy' context

Q14 How does X utilise its knowledge base to address socio-economic challenges?

Q15 How well connected is X to projects that can be classified as occurring in a knowledge-economy paradigm?

Is there anything else you would like to share regarding the subject?

Would you be willing to respond to a short email follow up, if required?

Ends.

Appendix B PhD research: Informed consent form

Title: Universities in the knowledge economy in South Africa and India: Trends, tropes, positioning

Please initial box

I confirm that I have read and understand the information sheet for the above study and have had the opportunity to ask questions. ☐

I understand that my participation is voluntary and that I am free to withdraw at any time without giving a reason. ☐

I understand that the researcher will not identify me by name in any reports using information obtained from this interview and that the views I express will remain confidential; or ☐

I agree to my name being listed as a participant in this study in the annexure to the report. ☐

I agree to the interview being audio recorded. ☐

I agree to the use of anonymised quotes in the dissertation. ☐

I agree that data gathered from me in this study may be stored (after it has been anonymised) and may be used for future research. ☐

Name of Research Participant **Date** **Signature**

Name of Researcher **Date** **Signature**

Appendix C Higher education in India, ~~an international comparative analysis~~[25] Semi-structured interview guide

Request: Kindly assist the interviewer by responding to a limited number of questions for the purposes of PhD research. This document serves as introduction for the interviewee. The interviewer will conduct a one-on-one interview using an MP3 recorder to record the responses. The interview should take a maximum of one hour, averaging 4 minutes per response. These responses will be coded later for analysis.

Introduction: The subject of "universities in the knowledge economy" is a growing area of interest to scholars and practitioners in African and Asian societies. For the purposes of this research, the concept "knowledge economy" refers to a society in which the rate of production of new knowledge, of inventions and prototypes, of patents and licences, of knowledge for social development, of applications of indigenous knowledge, has increased rapidly, speeded up by the relative ease of accessibility to this knowledge, through extended global institutional networks and the Internet, as well as through increases in R&D funding across the globe. *Innovation*, in all institutions and institutional practices, is the key word.

The purpose of the research is to examine whether and how academic research activity and teaching paradigms at universities are shifting, including possible shifts towards practices of "excellence", "entrepreneurial science", "open access", or "triple helix" relationships between government-industry-universities, and based on the findings, to elucidate how research-based South African universities could proceed to position themselves in the emerging "knowledge-based economy".

[25] The reference to comparative analysis is deliberately crossed out as the stages of grounded theory research that followed the first India data collection phase ruled out comparative analysis as an analytical methodology

The India ~~comparative~~ chapter will review perspectives from the following five universities (University of Delhi, Jawaharlal Nehru University, Jamia Millia Islamia University, Indian Institute of Technology Delhi, All India Institute of Medical Science) and three higher education related institutions, namely the UGC, the AICTE and the National Knowledge Commission.

The research pursues a multiple case study methodology, using grounded theory techniques for coding responses. As this is a qualitative study, the interviewer is interested in the content of the responses and the views of the respondents regarding changes and developments in the various institutions as reflected in the questions below, not in any numerical data.

Name of Institution:

Name and Position of Interviewee:

Date and Time of Interview:

General Background:

Q1 Please share your story of the university/organisation in the past ten years – the transitions, successes and failures from a "knowledge economy" perspective.

Perspective on the University (internal focus)

Q2 What are the University's existing areas of excellence?

Perspective on Research @ Jawaharlal Nehru University

Q3 Does JNU's research practice and paradigm promote research "excellence", "entrepreneurial research", "open access and open educational resources", or "triple-helix" relationships (university-government-industry linkages), or other modes of innovation? Give an example, explaining the challenges.

Q4 What are JNU's processes for promoting innovation-focused research outputs?

What measures does JNU employ to increase the participation of men and women, in research and publishing?

Q5 How well does JNU use ICT products and services to enhance research outputs?

Q6 How well does JNU mobilise government and private finance to support its research and innovation-focused activities?

Perspective on innovations in teaching and learning

Q7 What are JNU's successful models of inter-disciplinary or multidisciplinary teaching and learning?

Q8 Is innovation occurring in teaching at JNU in order to

(i) increase graduate throughput?

(ii) renew the knowledge base available to students?

Q9 How well does JNU use ICT products and services to enhance teaching and learning?

Perspective on talent, gender and minorities

Q10 What levers does JNU use to attract, enrol and graduate students with special attention to minorities and gender?

Q11 What measures does JNU employ to increase the participation of men and women in leadership and decision-making in the University, at the level of the Professoriate?

Perspective on the large research-based university in the broader 'knowledge economy' context

Q12 How does JNU utilise its knowledge-base to address India's key socio-economic challenges, namely growth and poverty?

Q13 How well connected is JNU to Indian projects that can be classified as occurring in a "knowledge-economy" paradigm?

Is there anything else you would like to share regarding the subject?

Would you be willing to respond to a short email follow up, if required?

Appendix D List of documents and websites reviewed by chapter

The documents and websites listed here were reviewed and relevant data extracted as reported in chapters 4 to 8. Some documents were used to provide the contextual discussion in chapter 10. Many of the documents are properly referenced in the bibliography above as they are cited in the text. The documents and websites are listed here to enable the reader to see the extensive set of data sources used for the thesis.

Chapter 4 Perspective on changing paradigms in higher education in India

(1) All India Council for Technical Education: Conference overview document, National conference on development of technical education in India, 17-18 December, 2007, New Delhi.

(2) All India Council for Technical Education website review (http://www.aicte-india.org)

Dutta, S. (ed) (2012). The global innovation index 2012: Stronger innovation linkages for global growth, INSEAD, Fontainebleau and WIPO, Geneva: provided data on the context of higher education research in India.

(3) Government of India (1987): The All India Council for Technical Education Act No. 52 of 1987.

(4) Government of India (1956): The University Grants Commission Act (as modified up to 20th December 1985) and rules and regulations under the Act.

(5) Indian Institute of Technology (IIT) Delhi website review (http://www.iitd.ac.in) in December 2007: led to the request for interview with the Transportation Research for Injury Prevention Programme located at IIT Delhi.

(6) Jamia Millia Islamia (JMI) website review (http://jmi.ac.in) in December 2007: led to requests for three interviews (two researchers and a senior manager).

(7) Jamia Millia Islamia annual report 2010-2011.

(8) Jawaharlal Nehru University (JNU) Delhi website review (http://www.jnu.ac.in) in December 2007: led to requests for interviews with two researchers (in arts and aesthetics; life sciences and bioinformatics) and a senior manager of the university.

(9) Jawaharlal Nehru University 38th annual report (1 April 2007 to 31 March 2008).

(10) Management Development Institute website review (http://www.mdi.ac.in) in December 2007: offered insight into an autonomous business school.

(11) Management Development Institute information brochure 2008: School for thought leaders and change masters, MDI, Gurgaon.

(12) Management Development Institute strategic plan 2007-2017, MDI, Gurgaon.

(13) Mizoram University website review (www.mzu.edu.in)

(14) Mizoram University annual report 2007-2008.

(15) NISTADS annual report 2005-06, National Institute of Science, Technology and Development Studies, New Delhi.

(16) National Knowledge Commission report to the nation 2007: provided data on policy change initiatives in higher education, increasing the complexity within universities and with respect to university research.

(17) National Knowledge Commission report to the nation 2006: provided data on policy change initiatives in higher education, increasing the complexity within universities and with respect to university research.

(18) OECD science, technology and industry scoreboard 2011: Innovation and growth in knowledge economies. http://dx.doi.org/10.1787/sti_scoreboard-2011-en: provided data on the context for higher education research in India.

(19) University Grants Commission website review (www.ugc.ac.in): provided background information on numbers and distribution of central, state, deemed and private universities in India.

(20) Visva-Bharati website review (www.visva-bharati.ac.in) in December 2007 and February 2014.

Chapter 5 Transitions in research practice and institutional research capacities

(1) Annual research reports for the University of the Witwatersrand for the years 2006-2012 inclusive (7 sets of annual reports).

(2) Annual research reports for the University of the Witwatersrand for the years 2008-2012 inclusive (5 sets of annual research reports).

(3) Gauteng City-Region Observatory annual report 2012/2013.

(4) Information brochures for the six Wits 21st century institutes (7 documents): The Wits 21st century research institutes: Aiming for the top; Sydney Brenner Institute for Molecular Bioscience; The City Institute; The Evolutionary Studies Institute; The Global Change and Sustainability Research Institute; The Institute for Wellbeing and Development; Wits Mining Research Institute

(5) South African Institute of Distance Education: Status report on ICTs and higher education in South Africa, 18 May, 2007.

(6) Square Kilometre Array Africa (n.d.). African SKA journey information brochure.

(7) University of the Witwatersrand (2 sets of faculty research plans): Faculty of Commerce, Law and Management Faculty research plan 2007-2012; Faculty of Health Sciences research plan, March 2008 (obtained from Wits Research Office).

(8) University of the Witwatersrand (4 sets of faculty research reports for 2012 to the University Research Committee): for the Faculty of Commerce, Law and

Management, Faculty of Health Sciences, Faculty of Humanities, Faculty of Science (obtained from Wits Research Office).

(9) University of the Witwatersrand (internal document): A bibliometric analysis of the state of research at WITS. Report prepared by Johann Mouton for the Wits Strategic Planning Division.

(10) University of the Witwatersrand (internal discussion document): Wits 21st century institutes: A strategic initiative of the Vice-chancellor.

(11) University of the Witwatersrand (3 sets of internal statistics drawn from management information systems):

- Human resource statistics by faculty for the years 2006, 2009 and 2012 (obtained from Wits Human Resource Information Systems).
- Postgraduate number of qualified students by faculty for the years 2003, 2006, 2009, 2012 (obtained from Wits Business Intelligence).
- Publications reports per faculty for the years 2009 and 2012 (obtained from Wits Research Office).

(12) University of the Witwatersrand (4 strategy documents):

- Wits 2013 strategy, Towards global top league status.
- Wits: Wits Vision 2022 strategic framework.
- Wits: Vision 2022 strategic framework, Report on the consultation process.
- Wits' strategic plan for research: 2012-2017.

(13) University of the Witwatersrand (5 sets of minutes of governance body): SET[26] retreat minutes 12 November 2011; SET retreat minutes 12 March 2012; SET retreat

[26] SET is senior executive team

minutes 16-17 November 2012; SET retreat minutes 12-15 June 2013; SET retreat minutes 13-15 February 2014.

(14) University of the Witwatersrand: Wits 2010 report: Realities and perceptions.

Chapter 6 Case study A: 21st century knowledge partnerships and institutional evolution at the JCSE

(1) Department of Trade and Industry and the Canadian International Development Agency (2000). South African ICT sector development framework (SAITIS), Summary, November 2000.

(2) JCSE annual reports 2001-2012 and 2012-2013 (2 sets of annual reports).

(3) JCSE proposal document: Wits Institute for Data Sciences and Policy Studies, version 3.4, 30 March 2013 (and multiple versions).

(4) JCSE website review (www.jcse.org.za)

(5) IBM briefing documents to the Department of Trade and Industry presentation session, February 2013.

(6) OPEN (n.d.). OPEN collaborative city workspaces information brochure.

(7) Tech-in-Braam emails and minutes of meetings September to December 2012.

(8) UKFIET International Conference on Education and Development – Education & Development Post 2015: Reflecting, Reviewing, Revisioning. Oxford, 10-12 September 2013, Paper presentation by Anne Skelton, University of Pretoria on South African 'mud schools', a way of reflecting on the value offered by the electronic case management system designed for the Legal Resources Centre by the JCSE.

(9) University of the Witwatersrand: Applied computing information brochure.

Chapter 7 Case study B: Knowledge for communities

(1) Agincourt website review (http://www.agincourt.co.za)

(2) Agincourt publications count 1992 to 2012: emails

(3) Faculty of Health Sciences: Biennial research reviews 2008-09 and 2010-2011 (2 sets of review documents).

(4) Health Sciences Research Office (HSRO) information brochure.

(5) Artefact: International Journal of Epidemiology 41 (2012). Review of artefact, namely a multi-authored open access journal article setting out the history and key outputs of the Agincourt health and demographic surveillance system.

(6) Artefact: Scandinavian Journal of Public Health (2007). Review of artefact Supplement 69: Health, population & social transitions in rural South Africa, reviewed in order to reflect on the emergence of this knowledge field for South Africa and the value of open access publication on the subject of health transitions.

(7) University of the Witwatersrand: Business case for Wits Rural Facility.

(8) University of the Witwatersrand: The Wits knowledge hub for rural development (vision document).

Chapter 8 Case study C: Institutional knowledge production, knowledge ownership and open access to knowledge

(1) Republic of South Africa (2008). Intellectual property rights legislation: Intellectual Property Rights from Publicly Financed Research and Development Act No.51 of 2008, Government Gazette No. 31745, 22 December 2008.

(2) United Nations Educational Scientific and Cultural Organisation (UNESCO). Berlin 10 open access conference programme, Networked scholarship in a networked world: participation in open access.

(3) University of the Witwatersrand SPARC seminar: Open access policy in building research profile and culture. Presentation by Prof T Cochrane, DVC (Technology, Information and Learning Support) Queensland University of Technology, Wits SPARC seminar on research productivity, open access and international visibility, Wits Professional Development Hub, 9 November 2012.

(4) University of the Witwatersrand SPARC seminar: Thinking through the research value chain: Patenting and commercialisation of inventions, copyright and open access publishing at Wits. Presentation by Prof V Pillay, scientist at the University of the Witwatersrand, SPARC seminar on research productivity, open access and international visibility, Wits Professional Development Hub, 9 November 2012.

(5) University of the Witwatersrand SPARC seminar: Seminar notes. Wits SPARC seminar on research productivity, open access and international visibility, Wits Professional Development Hub, 9 November 2012.

(6) University of the Witwatersrand: Intellectual property policy, approved by SET 25 September 2012, noted by Council 5 October 2012.

(7) University of the Witwatersrand review of library website (www.wits.ac.za/library)

(8) Wits Commercial Enterprise website review (http://wits-enterprise.co.za/) conducted over the period 2011-2012.

Chapter 10

Cape Peninsula University of Technology (2012). Cape Peninsula University of Technology research report 2011: contextual documents for application of theory.

Center for Higher Education Transformation website review (http://chet.org.za/): identified useful documents to frame the African context for theory of entanglement and university research activeness in emerging knowledge economies.

Department of Science and Technology: Ministerial Review Committee on the Science, Technology and Innovation Landscape in South Africa, Final Report. March 2012.

National Advisory Council on Innovation (2006). The South African national system of innovation: Structures, policies and performance, Background report to the OECD country review of South Africa's national system of innovation, 21 July 2006.

National Advisory Council on Innovation (2004). A profile of postgraduate higher education and the academic research community in South Africa, January 2004.

Organisation for Economic Co-operation and Development (OECD). OECD territorial reviews: The Gauteng City-Region, South Africa: contextual documents for application of theory.

Southern African Regional Universities Association (SARUA) (2007). Science & technology: A baseline study on science and technology and higher education in the SADC region. Studies Series 2007: contextual documents for application of theory.

UCT Alumni News (2012). (Article: Faculty of Health Sciences Centenary, 1912-2012) pp.4-9: contextual documents for application of theory.

University of Cape Town: 2011 research report: contextual documents for application of theory.

University of the Free State: 2011 annual research report: contextual documents for application of theory.

Vaal University of Technology: 2011 annual research report: contextual documents for application of theory.

Appendix E List of observation and participant observation incidents

The following list presents specific observation incidents for the data collection, in addition to generalized observation over the period of the study.

Observation incident 1: OECD review workshop, attended by senior leadership of universities and research institutions in the national system of innovation, The Innovation Hub, Pretoria, 31 July 2007.

Observation incident 2: Wits strategic retreat, attended by the VC, DVCs, Deans, Heads of School and other university administrators, Valley Lodge, Magaliesburg, November 2007.

Observation incident 3: National Conference on Development of Technical Education in India, organized by the All India Council for Technical Education (AICTE), attended by senior leadership of universities, institutes of national importance and colleges, National Agricultural Science Complex, New Delhi, 17-18 December 2007.

Participant observation incident 4: Wits SPARC workshop on innovation, knowledge transfer and partnerships between universities and government, Hofmeyer House, 18 July 2008 (email train 4-7 July 2008).

Participant observation incident 5: Guided tour of Centre for Rapid Prototyping and Manufacturing, Central University of Technology, Free State, 30 July 2009.

Participant observation incident 6: Wits SPARC workshop on partnerships and an IT-savvy university, Hofmeyer House, 13 July 2011.

Participant observation incident 7: Research workshop pertaining to CSIR/DST/IBM collaboration on the Skills Development and Research Institute, attended by CSIR, Department of Science and Technology, IBM and 24 participants from Wits, CSIR International Convention Centre, Lynwood, Pretoria, 31 July 2012.

Participant observation incidents 8 (group of meetings): Tech-in-Braam meetings, attended by representatives of City of Joburg municipality, JCSE, LINK Centre, Microsoft and IT entrepreneurs, held at Thoughtworks, Braamfontein, one hour meeting every second Tuesday September to December 2012

Participant observation incident 9: Wits SPARC seminar on "Research Productivity, Open Access and International Visibility", Wits Professional Development Hub, Braamfontein, 9 November 2012.

Observation incident 10: Presentation session on the proposed IBM Skills Development and Research Institute, attended by IBM, Department of Trade and Industry, Joburg Centre for Software Engineering, LINK Centre and University of the Witwatersrand, IBM Head Office, Sandton, 28 February 2013.

Observation incident 11: Wits partnerships workshop, attended by Wits academics researching the development of cities and representatives of the City of Joburg metropolitan municipality, Wits Club, 16 April 2013.

Participant observation incident 12: Wits Open Access workshop, attended by a general university audience, Senate House, 13 November 2013.

Participant observation incident 13: Wits-IBM partnership workshop, attended by IBM and Wits academics interested in ICT applications development, Wits Professional Development Hub, Braamfontein, 15 November 2013.

Participant observation incident 14: Visit to The Open at Maboneng Precinct to view collaborative working spaces, 5 December 2013.

Participant observation incident 15: Tshimologong Precinct Founders Event, 47 Juta Street, Braamfontein, 31 October 2013.

Observation incident 16: Research visit to Agincourt Health and Population Unit, Bushbuckridge and guided tour of study location, villages and local institutions, 11 March 2014.

Appendix F List of key informant interviews in India and South Africa

Number of interviewees	Key informant institution, position held and year of interview	Naming convention for attribution
1	Indian Institute of Technology (IIT) Delhi, Transportation Research for Injury Prevention Programme (TRIPP), key informant, 17 January 2008	IIT-TRIPP
2	Jamia Millia Islamia (university), professor of bioscience, 8 January 2008	JMI-PBS
3	Jamia Millia Islamia (university), professor of management studies, 27 December 2007	JMI-PMS
4	Jamia Millia Islamia, senior manager, 20 December 2007	JMI-SM
5	Jahawarlal Nehru University, professor of arts and aesthetics, 9 January 2008	JNU-PAA
6	Jahawarlal Nehru University, professor of life sciences and bioinformatics, 8 January 2008	JNU-PLS+BI
7	Jahawarlal Nehru University, senior manager, 24 December 2007	JNU-SM
8	Jahawarlal Nehru University, professor at Zakir Husain Centre for Educational Studies, 16 December 2007	JNU-ZHCES
9	Management Development Institute Gurgaon, professor of management studies, 19 December 2007; follow-up interview 10 February 2014	MDI-PM
10	Management Development Institute Gurgaon, professors of management studies, 18 January 2008: small group interview	MDI-PPM
11	Management Development Institute Gurgaon, professor of organisational behaviour, 11 January 2008	MDI-POB
12	Mizoram University, past senior manager, 15 January 2008	MU-SM
13	Visva-Bharati University, past senior manager, 16 January 2008	VBU-SM
14	University Grants Commission, past secretary, 17 January 2008	UGC-S

15	Agincourt Health and Population Unit scientists, 2008: small group interview	AHPU-S1/2-FG
16	Agincourt Health and Population Unit scientist, 2014	AHPU-S3
17	Agincourt Health and Population Unit scientist, 2014	AHPU-S4
18	JCSE client – LRC, 2014	JCSE-LRC
19	JCSE client – Microsoft App Factory, 2014	JCSE-MAP
20	JCSE researcher and scientist, 2014: small group interview	JCSE-RS
21	JCSE scientist, 2008	JCSE-S
22	Wits Central Network Services, 2014	Wits-CNS
23	Wits Commercial Enterprise research-IP manager 1, 2012	Wits-ERM1
24	Wits Commercial Enterprise research-IP manager 2, 2012	Wits-ERM2
25	Wits Commercial Enterprise, 7 February 2014	Wits-E
26	Wit Commercial Enterprise research-IP managers 1,2 and 3, 2014: small group	Wits-ERM
27	Wits e-learning, key informant, 2014	Wits-eLSI
28	Wits library, key informant, 2014	Wits-L
29	Wits Rural Facility external research service provider, key informant 2009 and 2014	Wits-RFSP
30	Wits researcher-innovator, 2012	Wits-RI
31	Wits Rural Knowledge Hub, key informant, 2014	Wits-RKH
32	Wits, senior manager (institutional perspective), 2014	Wits-SM1
33	Wits, senior manager (strategy perspective), 2008	Wits-SM2
34	Wits, senior manager (strategy perspective), 2014	Wits-SM3
35	Wits, scientist, 2008	Wits-EGRI