Case Studies of Use-Oriented Research

David Cooper
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Preface

As outlined in the Introduction to Part 1, and in more detail in Appendix 1, the project of which this book is the main output spanned a period of just over 10 years, beginning in 2000. I am thus indebted to many people, of whom only the main ones can be acknowledged here.

Firstly, I wish to acknowledge the directors and researchers of each of the 11 research groupings in the universities and universities of technology of the Western Cape, which formed the case studies of Part 2. In the interests of anonymity, I cannot identify them but I wish to express my deep appreciation of the time and generous support that they gave me for the lengthy interviews and document-collection process. Without this support, the arguments and theoretical framework embedded in this study would never have emerged. Similarly, I wish to salute the group who undertook the first phase of interviews in 2000: research assistants Carlene Davids, Deon Ruiters, Chupe Serote, Rosemary Wolson, and especially senior researchers Drs Alexandra Hoffmanner and Sharman Wickham, who produced such excellent interview material that I was encouraged to build on it, by my undertaking a second phase of interviews with each of the research groupings in 2005, and a third phase in 2007.

For encouragement to embark on the first phase of the project, I am indebted to David Kaplan who in 2000, as director of the Science and Technology Policy Research Centre at the University of Cape Town, helped me secure funding and helped in my early conceptualisation of issues around ‘unlocking university knowledge for society’, which theoretical scaffolding grew as my book expanded into its eventual title of *The University in Development*. For the second phase of interviews in 2005, I am grateful to Michael Kahn, then Executive Director of the Knowledge Systems Research Programme of the HSRC, who helped me secure funding and who gave generously of his ideas, which later culminated in his co-authorship of the Introduction to Part 2 of this book. Thanks also to David Lincoln who, in 2008/2009, stood in for me briefly as Head of Department of Sociology, so that I might complete the analysis phase. I am also grateful to Tara Weinberg for creating some of the figures in this book. And I will keep memories of the discussions with my friends Jonny Myers and Sue Myrdal, who over the years spanning this project always helped me to maintain optimism.

Final editing of the book after 2008 took longer than I expected, with Regine Lord, Doug van der Horst and particularly Biddy Green playing important parts. In particular, I must express my admiration for the editing skills and especially intellectual acumen of Karen Press, who quickly grasped the core themes of the
book and helped shorten it in such a collegial way. During the last six months of
production, collegial advice about editing from Brenda Cooper, Zimitri Erasmus
and Ian Scott helped me take courage when tasks seemed daunting. Finally too, I
am indebted to Roshan Cader and Inga Norenius and their team at HSRC Press who
helped steer through the final publication efficiently. I am also very grateful to the
UCT Research Office for providing a generous grant towards the costs of producing
the book.

Every one of the above-named acted as friends as well as colleagues at work. However I need to acknowledge three people who made special contributions, often
not intentionally, without which this book would never have emerged in the form it
finally did. My son Adam read a few chapters while in China in 2005 and encouraged
me in the following years to continue with the theoretical journey and further phases
of interviews, while my daughter Sara saw clearly some of the difficulties of finalising
the book and came forward with insights and encouragement. Particularly to Judy,
my wife, who lived through a decade of regular stories about the book and my
cycles of anxiety about achieving 'strong knowledge’ via sociological analysis, I am
forever grateful, including for the way she created mental and physical spaces for my
work. These are three special people to whom I dedicate the book, in the hope that
I will not disappoint the faith they continuously showed in my project: to produce
a relative degree of strong knowledge so as to influence change in research policies
and practices at our South African universities, around what I have termed the global
second academic transformation.
# Abbreviations and acronyms

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<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>AAU</td>
<td>American Association of Universities</td>
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<tr>
<td>AD–AC</td>
<td>Academic Department–Agriculture Centre</td>
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<tr>
<td>ANC</td>
<td>African National Congress</td>
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<td>ARC</td>
<td>Agricultural Research Council</td>
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<td>BERD</td>
<td>business expenditure on R&amp;D</td>
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<td>BRIC</td>
<td>Biotechnology Regional Innovation Centre</td>
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<tr>
<td>CNRS</td>
<td>Centre National de la Recherche Scientifique</td>
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<tr>
<td>CoE</td>
<td>centre of excellence</td>
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<tr>
<td>CS</td>
<td>civil society</td>
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<tr>
<td>CSIR</td>
<td>Council for Scientific and Industrial Research</td>
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<tr>
<td>DACST</td>
<td>Department of Arts, Culture, Science and Technology</td>
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<tr>
<td>DoE</td>
<td>Department of Education</td>
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<tr>
<td>DST</td>
<td>Department of Science and Technology</td>
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<tr>
<td>EPU</td>
<td>Education Policy Unit</td>
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<tr>
<td>ERA</td>
<td>European Research Area</td>
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<td>ERC</td>
<td>Engineering Research Centre</td>
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<tr>
<td>EU</td>
<td>European Union</td>
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<tr>
<td>FP</td>
<td>framework programme (of the EU)</td>
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<td>FRD</td>
<td>Foundation for Research Development</td>
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<tr>
<td>FTE</td>
<td>full-time equivalent</td>
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<td>GDP</td>
<td>gross domestic product</td>
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<td>GERD</td>
<td>Gross Expenditure on R&amp;D</td>
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<td>GNN</td>
<td>government national network</td>
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<td>GNP</td>
<td>gross national product</td>
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<tr>
<td>HEI</td>
<td>higher education institution</td>
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<td>HERD</td>
<td>higher education R&amp;D</td>
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<td>HoD</td>
<td>head of department</td>
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<td>HSRC</td>
<td>Human Sciences Research Council</td>
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<td>ICT</td>
<td>information and communications technology</td>
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<td>ILRIG</td>
<td>International Labour Research and Information Group</td>
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<td>IP</td>
<td>intellectual property</td>
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<td>ISG</td>
<td>International Study Group</td>
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<tr>
<td>IT</td>
<td>information technology</td>
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<tr>
<td>IUCRC</td>
<td>Industry/University Cooperative Research Centre</td>
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<tr>
<td>MIT</td>
<td>Massachusetts Institute of Technology</td>
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<tr>
<td>MMURC</td>
<td>multipurpose, multidiscipline university research centre</td>
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<tr>
<td>NASA</td>
<td>National Aeronautics and Space Administration</td>
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<tr>
<td>NATO</td>
<td>North Atlantic Treaty Organisation</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>NCE</td>
<td>network of centres of excellence</td>
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<td>NDRC</td>
<td>National Defense Research Committee</td>
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<td>NGO</td>
<td>non-governmental organisation</td>
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<td>NIH</td>
<td>National Institutes of Health</td>
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<td>NoE</td>
<td>network of excellence</td>
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<td>NRF</td>
<td>National Research Foundation</td>
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<td>NSF</td>
<td>National Science Foundation</td>
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<td>NSI</td>
<td>national system of innovation</td>
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<tr>
<td>NTC</td>
<td>Nanoscience and Technology Centre</td>
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<tr>
<td>OECD</td>
<td>Organisation for Economic Cooperation and Development</td>
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<tr>
<td>ONR</td>
<td>Office of Naval Research</td>
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<tr>
<td>ORU</td>
<td>organised research unit</td>
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<tr>
<td>OSRD</td>
<td>Office of Scientific Research and Development</td>
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<tr>
<td>OTL</td>
<td>office of technology licensing</td>
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<tr>
<td>PAR</td>
<td>Pure Applied Research</td>
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<td>PBR</td>
<td>Pure Basic Research</td>
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<tr>
<td>PD</td>
<td>postgraduate diploma</td>
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<tr>
<td>PI</td>
<td>principal investigator</td>
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<tr>
<td>R&amp;D</td>
<td>research and development</td>
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<tr>
<td>S&amp;T</td>
<td>science and technology</td>
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<tr>
<td>SARChI</td>
<td>South African Research Chairs Initiative</td>
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<tr>
<td>SET</td>
<td>science, engineering and technology</td>
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<tr>
<td>SETA</td>
<td>Sector Education and Training Authority</td>
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<tr>
<td>SOE</td>
<td>state-owned enterprises</td>
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<tr>
<td>SRC</td>
<td>science research centre</td>
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<tr>
<td>STC</td>
<td>Science and Technology Centre</td>
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<tr>
<td>SYS</td>
<td>Stanford-Yale-Sussex</td>
</tr>
<tr>
<td>THRIP</td>
<td>Technology and Human Resources for Industry Programme</td>
</tr>
<tr>
<td>TNC</td>
<td>transnational corporation</td>
</tr>
<tr>
<td>TTO</td>
<td>technology transfer office</td>
</tr>
<tr>
<td>UCT</td>
<td>University of Cape Town</td>
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<tr>
<td>UIBR</td>
<td>use-inspired basic research</td>
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<tr>
<td>U–I–G</td>
<td>university–industry–government</td>
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<tr>
<td>UIRC</td>
<td>university–industry research centres</td>
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<tr>
<td>UK</td>
<td>United Kingdom</td>
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<tr>
<td>UoT</td>
<td>university of technology</td>
</tr>
<tr>
<td>URC</td>
<td>university research centre</td>
</tr>
<tr>
<td>USA</td>
<td>United States of America</td>
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A global second academic transformation: In symbiosis with a third capitalist industrial revolution
Introduction: Investigating Western Cape university research groupings

The research for this study involved an in-depth investigation of 11 research groupings at Western Cape universities. The investigation incorporated detailed interviews with key members of each grouping in 2000, further follow-up interviews in 2005 and 2007, and final analysis of each case in 2009 – a project thus spanning nearly a decade. It is therefore useful to begin the presentation of the findings of the investigation with an outline of how the central theoretical issues of the study were conceptualised at the start of the process.

The research project was conceived in the late 1990s, influenced by my personal experiences of South African university research centres and units, as well as by the international literature on emerging new modes of research (e.g. Gibbons et al. 1994) and the ‘mushrooming’ of new types of research groupings within universities globally, alongside the more traditional heartland of academic departments (e.g. Clark 1998). Both these sets of influences helped shape my central question of concern: how might universities unlock – more creatively and productively – the knowledge embedded in these research centres and units, for (and in mutual association with) the wider society?

With regard to the context of personal experience, my academic work at that time was shaped by my role as an associate researcher of the Education Policy Unit (EPU), later renamed the Centre for the Study of Higher Education, of the University of the Western Cape. In the 1990s, the EPU was involved in what it called policy research for the new African National Congress (ANC) government and allied organisations, and what I now call ‘engaged scholarship’ (see Chapter 3) for a range of higher education bodies including the historically black universities (Subotzky 1997). This work within a research grouping like the EPU made me aware of what I later was to term the combination of ‘creativity and chaos’ of such new research centres/units at our universities (Cooper 2001). It involved enormous creativity (and commitment) on the part of its researchers, but at the same time included a series of blockages and impediments (lack of funding, insecure careers for contract researchers, unclear procedures for how the centre fitted in to a university, etc.). My encounters during the 1980s–90s with similar mushrooming research groupings at other universities of the Western Cape and also nationally, as well as at some technikons where I undertook research (Cooper 1995), suggested that something structural underlay the tendency of these research groupings to veer towards ‘chaos’ (or even demise). So it seemed relevant to undertake an in-depth investigation of a sample of such new
centres and units in the Western Cape region, in order to examine more closely the inhibiting factors being experienced by these research groupings.

With regard to the literature on research groupings of this kind, in South Africa in the late 1990s there had been no serious studies of the workings and dynamics of such groupings (although in the following decade such research began to develop; see for example Kruss 2005, 2006). Nonetheless, I was influenced by some international work on what might be termed the ‘new academic transformation’ with regard to new university centres and units globally. For example (but see Chapters 1–3 for a more detailed review), Clark's (1998) study of five ‘entrepreneurial universities’ in Europe in the 1990s seemed very relevant. In particular, his argument about such universities responding to the needs of industry seemed to provide considerable insight into the way that such academic entrepreneurship was resulting in what he termed an ‘expanded development periphery’ of research centres and units, emerging alongside (but usually peripheral to) the traditional, discipline-based teaching–research departments. Embedded in his analysis, too, was a fruitful idea: that some of the blockages experienced by these innovative research groupings were due to a conflict between the ‘traditional’ and ‘new’ structures and processes of these universities. Studies emerging around the idea of a ‘learning region’ (e.g. Goddard 2000), and how universities might respond to their locality in terms of socio-economic development, seemed also directly relevant to an allied question I was posing: how might the new research centres/units better fulfil what was being called the university’s third mission of development – alongside the two traditional missions of teaching and basic research (see discussion of Etzkowitz 1993 below) – a mission with relevance to the Western Cape and the country as a whole?

A further question seemed to emerge as quite central to all these dynamics: how did these university transformations around new centres/units and a third development mission link to changes in the global economy? Here I was influenced by a literature review by one of my graduate students (Orr 1997; see also Cooper 1997) on what was being called the ‘market university’ (e.g. Buchbinder 1993) – how the research of universities was increasingly being impacted on by forces of the capitalist market, leading to a growing commodification of university knowledge. Influential in South Africa at the time was the work of Slaughter and Leslie (1997), who suggested that within the new entrepreneurial universities, new forms of ‘academic capitalism’ were emerging. They argued that in a growing number of new fields like the biological sciences, particularly in the USA and other northern countries, academic scientists were increasingly becoming embedded in ‘market relations’ with industry – hence academic capitalism. Nonetheless, I had some reservations about this definition of capitalism purely as market relations; my own historical materialist orientation was influenced by a tighter definition of capitalism as a mode of production involving social relations of production and social forces of production (e.g. Cohen 1978; see also Table i.1). It was not clear to me how these new market-oriented scientists fitted into the new capitalism defined in this way as ‘mode of production’. Moreover, while I recognised the centrality of the social relations between those who owned and
controlled the means of production (be they small family firms or shareholders of transnational corporations [TNCs]; see Table 1.1) and those who sold their 'labour power' in the capitalist market, also important was something often under-stressed in traditional Marxist sociology – the importance of market competition between capitalist firms. Here new ideas in an emerging field of science and technology studies – made public in journals such as Research Policy and influenced especially by the work of Schumpeter (1950), which stressed capitalism as an engine of technological innovation – seemed particularly relevant. For, as argued by Nelson (1990) within a Schumpeterian framework, increasingly in the new phase of global capitalist competition, firms are turning to academic science to provide them with a competitive edge, that is, to provide them with the 'knowledge base' for their technological innovations. Clearly, therefore, within this cluster of emerging ideas about universities and a 'new capitalism', questions about how Western Cape research centres and units might unlock their knowledge in relation to society – for the benefit of both industry and other civil society (CS) organisations – seemed an important area of study.

New issues and perspectives: Their unfolding in the research process

In the chapters which follow in Part 1, I will seek to show that a new theoretical framework is needed to make sense of the case study material in Part 2 – a framework involving a 'bag of concepts' which I did not hold at the beginning of this research project in 2000. Such a set of concepts includes new ideas about a 'second academic transformation' and its links to a 'third capitalist industrial revolution' since the 1970s; how the latter is underpinned by university-based 'use-inspired basic research' (UIBR), which is a core component of the third mission, especially at research-intensive universities; and how all these link to new types of research groupings that I call 'real research centres' (which I designate as a Model A type) and 'virtual centre or professor-networks' (which I designate as a Model C type). I will argue further that these new concepts are interdependent, each requiring some grasp of the others in order to understand the new framework as a whole. For this reason, this Introduction to Part 1 will seek to provide the reader with an overview of this set of concepts and related issues – even though they will be explored more rigorously and systematically in the chapters that follow. This overview will be provided by means of a narrative that combines theoretical exposition with a personal account of how fundamentally new perspectives emerged as the research process unfolded during the three phases of interviews conducted between 2001 and 2007.

As noted above, the research process methods and findings that are documented in this book began in 2000 with an in-depth investigative project focusing on a small sample of 11 research groupings across the five Western Cape higher education institutions (HEIs). Specifically, the project defined its focus as follows:
The unlocking of intellectual knowledge: case studies of applied research centres and units at universities and technikons of the Western Cape.¹

The investigation aimed to consider a complex of issues relating to the structure and purposes of these HEI research groupings, and summarised these in the related set of questions:

What are the major factors currently affecting research centres and units at Western Cape higher education institutions, in terms of either enhancing, or inhibiting these research groupings from fulfilling their mission of applied research for wider societal constituencies…[and] how might HEIs and national bodies undertake reforms in their research administration structures and practices to enhance such applied research?²

The research process started on these terms and evolved through three phases of investigation: in 2000, in early 2005, and again in early 2007. At each of these stages the same 11 university research groups were interviewed and documentation collected. Importantly, a core question (‘How can university research groupings unlock knowledge in relation to society?’) remained constant throughout this period of nearly a decade, as did the related questions, namely, what are the most important factors impacting on Western Cape university groupings that have enhanced and/or inhibited their mission of application-oriented research; and what national and local policy reforms might be pursued in order to support such work?

Addressing these questions is a constant focus of the analysis presented in this book. The research process itself is another important theme since, as noted, during the lengthy research process a series of new issues and perspectives emerged which significantly altered the way I viewed the initial research questions.

More specifically, a new ‘theoretical scaffolding’ had to be constructed to reach a deeper understanding of the problems and challenges faced by these Western Cape research groupings in achieving what will be described in later chapters as their mission of ‘use-oriented research’ for the public good. At the core of this new theoretical framework is the argument that these research groupings are part of a quite fundamental academic revolution, what I have termed a ‘second academic transformation’, referencing Henry Etzkowitz’s definitions of a ‘first academic revolution’ of basic research in the 1800s and a ‘second academic revolution’ emerging in the latter part of the twentieth century, with its focus on use-oriented research (see for example Etzkowitz 2001; Etzkowitz’s ideas are discussed in some detail in Chapter 1). I argue further that it is vital to recognise and understand this second academic transformation, in order to analyse the current strengths and weaknesses of these research groupings and their capacity to contribute to some kind of broadly defined social development. Moreover, I propose that it is only possible to appreciate the strength of this university-based academic transformation if one views it as linked to an external, society-based revolution – a new post-1970s industrial revolution for which terms such as ‘the knowledge economy’ or a broader version, ‘the knowledge society’, are partly useful as descriptions. In fact, I hypothesise more
specifically that what has been occurring is a new ‘capitalist industrial revolution’ which has, especially since the 1980s, become symbiotically linked to this second academic transformation within our universities.

These concepts, of a second academic transformation and a new knowledge-based capitalist industrial revolution, provide the core of the framework for all the chapters that follow. They are linked to four important new perspectives and associated issues which emerged midway into the research process, and which helped significantly to shape the development of this new theoretical framework. I will briefly discuss each of them, although they are examined in greater detail later in Part 1, as well as in the analysis of the case studies in Part 2. These involve:

• the relationships between pure and ‘applied’ research;
• the research links between universities and ‘society’;
• the ‘mode’ of internal organisation of research groupings; and
• the ‘relative autonomy’ of university research.

Before exploring these themes further, however, I will contextualise the research by giving a very brief outline of how it was undertaken, its design and evolution.

The context and initial design of the research

Embedded within the research questions I posed at the beginning of the first phase of interviews in 2000 was the idea of ‘applied research’ (see the two quotations above from the original research proposal). The sampling approach of the investigation was thus to select such ‘applied’ cases rather than ‘pure research’ groups, because the latter were not seen as directly unlocking their knowledge for the wider society. In addition, the societal constituencies ‘external’ to the university, towards whom such applied research work was oriented, were seen as comprising a variety of interest groups and associations, including industry, government and civil society groupings such as labour and community organisations, non-governmental organisations (NGOs), etc. The applied research groupings were assumed to fall into the two main research-type categories commonly used in the Western Cape at the time: (larger) centres or (smaller) units. And finally, while the research project proposal did hypothesise that there were some significant changes under way in South Africa and internationally in relation to modes of applied research, it made no assumption that we were seeing the kinds of far-reaching changes that would warrant invoking the idea of a revolution in research forms and structures.

The project thus began with an investigation of the sample of 11 research centres and units located across the five universities in the Western Cape. Ten research groupings were specifically selected because of their involvement in ‘applied research’, while one was chosen because of its entire focus on ‘pure research’. In investigating each case, the main research methods comprised in-depth interviews and the use of documents and website information.

At a theoretical level, the original research proposal invoked Etzkowitz’s framework of first, second and third ‘missions’ of universities: ‘The first academic revolution,
taking off in the late 19th century, made research [the second mission] a university function in addition to the traditional task of teaching [the first mission]...A second academic revolution then transformed the university into a teaching, research and economic development [the third mission] enterprise' (Etzkowitz 2003: 110).

The proposal hypothesised the idea of ‘unlocking’ knowledge by mission-oriented research groupings – the mission being socio-economic–cultural development in the wider society. The project would thus focus on factors that enhanced and/or inhibited the work of research groupings with respect to their research productivity and innovation, in relation to Etzkowitz’s ‘third mission’ of universities.7

From the outset, therefore, the project was sympathetic to Etzkowitz’s proposition (for instance in Etzkowitz 1994) that since the 1980s we had been seeing a new, third mission of development alongside the earlier missions of teaching and research. I nevertheless still viewed this third mission as involving additions to, rather than major transformations of, university structures.

However, the first phase of the project, and its initial report (Cooper 2003b), generated substantial evidence of tensions that prevailed in all 10 of the application-oriented research groupings as they sought to combine these three missions. For example, most of the 10 research centres and units struggled to combine research with teaching, which impinged on their research productivity and hence on their third, development-oriented mission. Another problem was the evident tension experienced by the leaders of some of these research groupings, as they tried to function both in a (traditional) role as head of an academic department and in a (new) role as head of a relatively large research centre that was trying to fulfil a development mission in association with external constituencies such as industrial firms. There appeared to be a very strong conflict – even contradiction – between the ‘old’ structures and norms of these Western Cape universities, which facilitated the first two missions of teaching and (basic) research, and the ‘new’ situation in which these centres and units were clearly battling to make a novel third, developmental mission the focus of their activities.

As mentioned, in attempting to conceptualise such tensions and conflicts between the old and the new, my analysis of the cases began to consider the idea of a ‘combination of chaos and creativity’ in which these 10 groupings found themselves (Cooper 2001; also 2003a). It was clear to me that part of this chaos was a result of some of the ‘old’ university structures and norms blocking the unlocking of the knowledge that would enable these centres and units to achieve their third mission. What was not yet clear to me was that such a mission needed to be accompanied by what Etzkowitz called a ‘second academic revolution’ – involving quite radical changes in the systems and norms of academia within these universities. That such a major transformation of the older structures and rules was necessary to facilitate the ‘unlocking of university knowledge’ for societal development would gradually become evident, as I grappled with the case study evidence and the structural problems it highlighted.
The second phase of the research: Reconceptualising the central issues

I was helped towards this idea of a major new structural ‘academic transformation’, linked to the third mission, when I undertook the next phase of interviews in early 2005 to assess the changes that had taken place between 2000 and 2005. Later, during a summer break at the beginning of 2007, I undertook a third phase of interviews, again revisiting each of the 11 case studies. Eventually, therefore, I had a remarkably rich set of data snapshots for the period 2000–2005–2007, involving three moments in time. Such a spread is unusual for South African social science research, especially if it involves qualitative approaches which usually capture a single snapshot in time and hardly ever incorporate more than two. This process provided me with a valuable and unusual historical sociology of these 11 research centres and units.

My reconceptualisation of the central issues linked to the original research questions was triggered especially by the surprises I encountered during the return visits of 2005. I found, for example, that some of what I had viewed as the best research groupings in 2000 were unexpectedly confronting problems in early 2005, while some of the weaker groupings of 2000 were doing fairly well by 2005 (and even better by 2007). This suggested new ideas about the ways in which research groups, in order to fulfil their development mission, may organise themselves internally into what I call ‘model types’ of centres or networks or units (discussed further below). Similarly, the fact that most applied research groupings were found to be undertaking basic research at the same time, forced me to rethink the relationship between applied and fundamental research by developing a new idea of UIBR. And by 2007 it was becoming clear that these research groupings were part of a major transformation process taking place in research practices, in contrast to the earlier traditional forms of research. This led me to theorise that these transformations were linked not only to the new global ‘second academic revolution’ posited by Etzkowitz, but also to major external forces that had unfolded within the global political economy over the previous few decades – a global industrial revolution associated with a knowledge-based society. It is to these elements of my developing conceptual framework that I now turn.

Relationships between pure and applied research: The idea of UIBR

As noted, 10 ‘applied’ research groupings were selected during the first phase of interviews, together with one group involved in ‘pure’ research. The latter type of research I understood as basic or fundamental research – essentially curiosity-oriented work that seeks a fundamental understanding without concern for use.

However, during the analysis of the first-phase interviews it seemed that most of the applied groupings were actually involved in a combination of basic and applied work. For example, the research centre in Case 1 (analysed under the pseudonym ‘Agriculture Centre’ in Part 2) was involved in fundamental research in biogenetics, but always with an eye to its use in biotechnology applications in agriculture. In
fact, as will be seen in the analysis of this case, its major funders expected such bio-
applications to emerge from its fundamental research work. Since well over half the
‘applied’ sample cases seemed to fit this pattern, I introduced the term ‘fundamental-
applied research’ for this phenomenon (in Cooper 2003b) during the initial analysis.
In 2004, however, shortly before the beginning of the second phase of interviews,
I encountered with excitement the concept of UIBR through the work of Donald
Stokes (1997), which introduced this concept of UIBR ‘in between’ the concept of
Pure Basic Research (PBR) on the one side and Pure Applied Research (PAR) on the
other (as illustrated in Figure 2.1 of Chapter 2).10
Stokes’s concept of UIBR seemed to overcome an unhelpful and crude dualism
between PBR and PAR. It introduced the valuable concept of combining basic
research with ‘use-inspiration’ in one moment of research activity. Moreover, I
will argue that UIBR provides a far more insightful approach than the concept
of ‘strategic research’, which had been in vogue in South Africa (see, for example,
Mouton 2001). The term ‘strategic research’, at least as it was used at that time, did
not specify clearly the meaning of strategy (was it implying ‘applied research with
a long-term goal’?); but, more crucially, the term did not seem to incorporate the
essence of the idea of UIBR, namely that basic research is embodied within the ‘use-
oriented/inspired’ research strategy itself.
In my research process, a new perspective had emerged, leading to my (re)
construction of some issues along the lines of the following questions: Is it valuable
to go beyond the ‘basic-applied’ dichotomy? Does this facilitate an understanding of
how the 10 Western Cape research groupings undertook their use-oriented research
activities, incorporating both UIBR and PAR?
It seemed useful to shift, therefore, to a classification of these 10 cases as ‘use-
oriented’,11 and in each case to explore how, and to what extent, its research
incorporated UIBR alongside PAR. Moreover, the new issues concerning the
relationships between PBR, UIBR and PAR opened up a whole new terrain for
consideration. This terrain will be explored in Part 1, particularly with regard to the
idea that since the last quarter of the twentieth century we are seeing a global ‘second
academic revolution/transformation’ towards more use-oriented research in which
UIBR is central, especially at research-intensive universities.12 These conceptual
threads will also be carried forward into the case study analysis in Parts 2 and 3,
which consider, for example, the hypothesis that relatively more components of PAR
are to be found within Western Cape university of technology research groupings,
compared to a relatively greater incidence of UIBR within traditional, more research-
intensive university groupings.

Research links between universities and society: The dominance of
the ‘triple helix’

A concept that I use throughout this book is that of the ‘triple helix’. This term was
coined by Etzkowitz and colleagues to describe the university–industry–government
(U–I–G) triad of research relations linked to the third, development mission of research: ‘The Triple Helix thesis postulates that the interaction among university–industry–government is the key to improving the conditions for innovation in a knowledge-based society’ (Etzkowitz 2004: 64).

However, in the same way that I sought to extend Etzkowitz’s third mission concept of economic development into the more encompassing idea of socio-economic-cultural development, so I also deliberately sought to add to his triad of U–I–G relations the idea of university relations with civil society, that is, U–CS research relations, which are explored through an analysis of the Western Cape case studies. In 2000 I provisionally hypothesised that civil society comprised groupings external to the university, such as community and labour organisations and social movements, other ‘civic’ structures such as women’s or health or environmental or religious organisations, and NGOs and local and regional (metropolitan) administrative bodies/structures (see Chapter 3).

The first phase of interview data, however, suggested a dominance of U–I research relations, with national government generally playing some direct or indirect ‘coordinating’ role in terms of funding and other support structures. The triple helix thus seemed alive and strong in the Western Cape, with only one or two of the case studies involved in any civil society research relationships at all. Although this could be explained partly by the fact that a significant number of the cases that had been put forward for study by their university directors of research administration were in the science–engineering fields, the significant ‘skewness’ towards U–I relations that I was observing in 2000 could not be wholly explained by the sample selection. Moreover, after the second phase of interviews, it seemed that U–I relations were being consolidated even more across the cases, again with few civil society research relations.

Figure i.1 The ‘orphan’ U–CS link, alongside the U–I–G triple helix
I therefore began to seek reasons, within both the interview data and international literature on the third mission and triple helix, to explain why there was such a dominance of U–I–G relations, a situation which in effect created an orphan status for U–CS relations, as illustrated in Figure 1.1. For example, in international policy discourse on the idea of a national system of innovation (NSI), there appeared to be a concern only with U–I relationships, with national government acting as the mediator in initiating and managing these relationships. This seemed to be linked to a central issue of how industrial productivity in each capitalist country could be enhanced through university-based research in order to increase global competitiveness. In contrast, very little academic discourse appeared on the question of U–CS research linkages in any of the dominant international journals dealing with NSI issues (see Chapter 3).

Clearly, therefore, the centrality of the triple helix, evident also in the data from the 10 Western Cape use-oriented cases, seemed to pose much sharper questions than I had anticipated about the role of industry, which appeared here almost as a 'social movement' driving forward the research linkages with universities. By the time of the second phase of interviews, therefore, the U–I research relationship had become the most central issue to be considered in the analysis.

I nevertheless propose in this book to classify U–CS research relations as a ‘fourth helix’, and a sub-theme to be considered at various points will be why there is this marginalisation or peripheralisation of university linkages with civil society. I shall stress, especially in the concluding chapters, the importance of this missing concept of the fourth helix.

In the research process itself a new orientation had therefore emerged, linked to new issues and questions that I now wanted to include in the investigation: What are the international, national and local factors shaping the major dominance of U–I–G research relationships for each of the 10 use-oriented Western Cape research groupings? And to what extent does international literature on the third mission and triple helix treat what I have termed the ‘fourth helix’ as an absent category, thereby reinforcing the dynamics in South Africa towards strengthening U–I–G relations?

The internal organisation of research groupings: Three ‘model types’ for use-oriented research

When the initial interview data were examined after the first phase in 2000, I developed the idea that three of the research groupings could, in many ways, be viewed as model types (later referred to simply as models), as shown in Figure 1.2. Two of these were use-oriented groups: Model A was a relatively large research centre exemplified by Case 1 (the Agriculture Centre), while Model B was a smaller research unit exemplified by Case 2 (referred to as the Genes Unit in Part 2). I hypothesised that each of the other eight use-oriented cases could be analysed as variants of the larger centre-type internal structure or smaller unit-type internal structure.
Figure i.2 Research model types as hypothesised after the first phase of interviews

The essential elements – or core internal organisational structures – of these two models of use-oriented research (UIBR+PAR) are shown in Figure i.2. The smaller unit (Model B) is based around a professor as principal investigator (PI) and his/her small group of postgraduates and a few post-docs, often referred to as ‘my lab’ (in the sciences) or more generally as ‘my research group’. The larger centre (Model A) has a quite different and more complex structure, with a professor as director, leading a team of senior researchers (generally three or four scholars at the level of associate professor or higher); these ‘seniors’ themselves serve as PIs for their own subgroups of postgraduates and a few post-docs; and there is a relatively substantial administrative structure comprising secretarial, financial and technical staff, etc.

In terms of this conception of model types there is a third model, exemplified in the case studies in Part 2 by Case 0 (referred to as the Science Unit). This is the small traditional unit/group with a focus solely on curiosity-oriented PBR. I have called this the Model T unit, to indicate that it embodies an earlier form of research grouping which continues to exist in that traditional form. It too is headed by a professor as PI, with his/her small group of postgraduates and a few post-docs as part of the ‘lab’ or ‘research group’. Its internal structure is almost exactly the same as that of the Model B unit – in fact, I argue in Chapter 3 that its roots lie in the German research-chair system of professor-cum-small group of postgraduates and a few research assistants, a system that was established in the course of the ‘first academic revolution’ (Etzkowitz 1994) in the 1800s, which consolidated basic research at universities alongside teaching.
Thus, after the first phase of interviews, I hypothesised that we are seeing a new Model B small unit type emerging for use-oriented research, which in many respects is internally organised in the same way as the nineteenth-century-based Model T. However, a close look at Models T and B in Figure i.2 does show two very important differences. Firstly, while the traditional professor in Model T combines research with teaching, in Model B the activities related to the third, development mission have led its professor to focus on research and shed much or all of his/her undergraduate teaching duties; the category ‘professor-researcher-lecturer’ in the Model T unit becomes the ‘professor-researcher’ category in the Model B unit. Secondly, the small Model B unit is linked, through a use-oriented research programme and its developmental mission, to ‘clients’ who are often in industry and (sometimes) in civil society. In contrast, the curiosity-oriented PBR programme of the Model T unit is undertaken without concern for use.

As regards the Model A unit type, I argued, based on the phase-one interviews, that we are also seeing the global spread of this new, larger centre-type structure that is very different in internal configuration from the traditional Model T type, and even from the new, small Model B unit type (Cooper 2003b). In fact, I argued that this larger Model A type is often more efficient (for various reasons discussed in later chapters) in undertaking use-oriented research linked to the third mission than the Model B small unit type.

However, what I did not expect to find during the second phase of interviews in 2005 was that Case 1 (the Agriculture Centre, as exemplar of Model A), as well as one or two other similar large centre-type groupings, was experiencing considerable organisational instability and insecurity, especially with regard to funding. On the other hand, another grouping, Case 3 (referred to as the Space Lab research grouping in Part 2), seemed to be doing much better, and continued to do so when interviewed again in 2007 – yet it comprised a loose network or cluster of professors, each with their own subgroups and organised more informally in a common research programme of use-oriented research for clients. One or two other such loose clusters or agglomerations of professors coming together around a common research programme in 2005 also seemed to be relatively stable and productive, and continued to be so into 2007. This led me to hypothesise a further model type, Model C, a ‘virtual’ centre type comprising a network of professors-researchers and with an internal structure as shown in Figure i.3.14
Thus, through a series of steps, I began to reconceptualise the issues in terms of three use-oriented models as the foundation for the case study analysis, and posed the related questions as follows: Does the introduction of the idea of three ‘model types’ provide a fruitful way of analysing the strength and stability of the 10 application-oriented Western Cape research groupings? And does this help in assessing the factors that enhance and inhibit their research work?

Moreover, following this line of thought, I proposed by the end of the phase-three interviews to conduct the analysis of all 10 use-oriented research groupings in terms of the typology shown in Figure i.4 (an elaboration of the typology presented in Figure i.3).
In essence, I had arrived at the hypothesis that, in assessing the factors enhancing or inhibiting the research programmes and the ‘third missions’ of the remaining seven use-oriented cases (Cases 4–10), it would be valuable to consider each of these as ‘in transition’ between the traditional Model T, based on curiosity-oriented research, and one of the new model types (Models A, B or C) that are based on use-oriented research. In my discussion of the cases I will argue that some cases, for example Cases 4 and 5, are best viewed as ‘in between’ the traditional Model T and the new Model B small unit type; others, such as Cases 6 and 7, are in transition from a Model T structure to a new Model A large centre-type structure; while the remaining cases (8, 9 and 10) are best understood as in between Model T and the new Model C virtual centre type.

Most importantly, too, I hypothesise that with reference to the two larger and more internally complex centre types, namely Models A and C, we are seeing a quite different internal structure of research organisation, one that is very different from the traditional Model T structure of curiosity-oriented research. And I argue that these two model types are slowly becoming more dominant than the smaller Model B type with respect to undertaking use-oriented research. Finally, I argue that this mushrooming of the three new models is clearly linked to the third mission of societal development, and points to something important and new and different, namely a second academic transformation that moves universities beyond the state they attained as part of the first academic transformation defined by Etzkowitz (2001). In fact, as I argue later in Part 1, although Etzkowitz himself in various places in his work does point to the significance of the rise of new types of centres as evidence of the spread of the third mission, in general he underestimates their revolutionary importance in relation to this second academic transformation.
contrast, throughout this book I place these internal organisational changes in the nature of the research groupings at the centre of the major shift in academic research orientation currently taking place, away from the norms and values of the ‘traditional’ first academic transformation rooted in curiosity-oriented research (PBR) and towards a new concentration on UIBR and PAR.

The relative autonomy of university research: New forms of an older concept

During the second phase of interviews, it not only became clear that U-I research relations were absolutely central to most of the cases, but other important issues were also emerging linked to this. For example, were the research groupings themselves aware of international movements towards stronger triple helix relations? And how were they handling the closer relationship to industry? As regards the latter question, as noted earlier I was aware of the discussions at the time in South Africa relating to contemporary books such as Clark (1998) on the ‘entrepreneurial university’, and the findings in Slaughter and Leslie (1997) about what they argued was the spread of ‘academic capitalism’.

A range of international writings was thus raising issues of academic research culture and its linkages to industry. In my own evolving conceptual approach to the Western Cape cases, I also wondered whether industry funding was skewing research more in the direction of PAR than UIBR. And, more generally, there was the question of university research in relation to the wider society. Even under the traditional regime of (so-called) curiosity-oriented research, this autonomy of university research had always been a relative one (this is discussed further in Chapters 2 and 3); under the new pressures of expanding U–I–G relations, was even this relative autonomy being diminished?

Early in 2005 an important and unexpected occurrence in the unfolding of my research perspectives took place during my interview with a professor at the virtual centre (Case 3), which I was beginning to categorise as a ‘network of professors’ within what I had named the Space (virtual) Centre. At the time of the second phase of interviews I was exploring the international literature on the concept of a third mission of universities, and its links to Etzkowitz’s ‘second academic revolution’. My discovery of Etzkowitz's historical book *MIT and the Rise of Entrepreneurial Science* (2002) was particularly valuable in this regard. In this work, Etzkowitz argues that at the Massachusetts Institute of Technology (MIT) after the 1920s and at Stanford University just after the Second World War (thus long before the 1980s), one could observe the earliest features of a second academic transformation, with academics already struggling to combine a third, development-oriented mission (particularly related to engineering science research for industry) with their first and second missions of teaching and basic research. He further argues (perhaps somewhat optimistically) that the academic researchers at MIT in the 1930s managed by trial and error to evolve new ways of doing things that easily enabled them to combine excellent research with the third mission linked to industry. In other words, in terms
of the concept defined by Slaughter and Leslie (1997), Etzkowitz’s argument is that a culture of academic capitalism did not simply take over at MIT.

My assumption, borne out by experience at the time, was that while some South African academics and a few researchers within research groups were becoming familiar with debates about the third mission, no one appeared to have heard of Etzkowitz’s historical study of MIT and Stanford.15 A corollary of this was my assumption that Western Cape researchers were themselves grappling with the issues of linking up their research with industry, and were doing so through trial and error, with little or no explicit reference to international practices and ideas relating to a second academic transformation. So in March 2005, while immersed in the writings of Etzkowitz and others, I began the second phase of interviews with one of the Space Centre professors. The interview drew on the knowledge acquired during the interviews of 2000: about how a core group of four ‘Space’ professors from a university engineering department had taken nearly a decade in their departmental ‘Space Lab’ to do research with master’s and doctoral students in order to build a micro-satellite and launch it into space at the end of the 1990s; and how, after 2000, they had helped to establish in a science park near the university a ‘space company’, which marketed products allied to their engineering research.

A series of surprises emerged from my interview in 2005. One of these, as noted, was how relatively stable this ‘network of professors’ (Case 3 as an exemplar of Model C in Figure i.4) had been over the period 2000–05 compared to most of the other cases. But the biggest surprise came when I mentioned that I had recently been researching historical information about MIT and Stanford in relation to how their university engineering departments linked up with industry in ‘use-oriented’ research in the 1930s and 1940s:

Interviewer: You don’t have undergraduate students working on these [projects inside the Space Lab in the department]?

Prof. Q [professor in the engineering department]: No, no. [Elsewhere he explained that only master’s and doctoral thesis students are brought into this Space Lab]

Interviewer: But do you have any postgraduate students doing [consultancy] work in this [Space Lab] and directly employed by the company [in the nearby science park]?

Prof. Q: No, we’ve put up a clear artificial wall between what the company does, which is doing business, and what the university does, which is the research.

Interviewer: What is the basis of this – is it because of the money issue? Is it because this [more consultancy work] is not really new knowledge?

Prof. Q: No, because of role-drift.

Interviewer: Okay.
Prof. Q: When the university gets too involved in commercialisation, it takes our attention away from training and research. And if the company would try and do too much blue sky [basic science] work, then they won’t make a profit, because that’s not a profitable part of business.

Interviewer: Okay.

Prof. Q: But, we clearly know the role of the two entities; and because we know that well, we know where to cooperate. [So] this side [the university] is teaching; and this side [the company] is development, actually putting into practice.

Interviewer: Can I ask you, because I’ve been reading about the history of MIT, and we’re talking about the 1890s – even by 1920 they’re doing applied work [for industry], they’re even debating the role between what you’re talking about – commercial and blue sky…

Prof. Q: Ja, ja.

Interviewer: And then later in Stanford, after 1945 – so now, one of my theories is that this is already being developed, people were working this out in engineering departments in MIT and other places. Were you influenced in the way you worked by what you found overseas?

Prof. Q: Ja. Professor S [a colleague in the Space Lab] is a MIT graduate… Professor R [another colleague in the Space Lab] is a Stanford graduate…I am a Stanford graduate…So R, myself, we are both Stanford. We actually worked in their research labs for our PhDs.

Interviewer: So you saw them doing this [in the Stanford labs]?

Prof. Q: Ja, we worked there for our PhDs and we saw the model.

Interviewer: You saw how they related to industry?

Prof. Q: At Stanford there’s a campus with the research labs and the academics, and then there’s just one road and then so-called Silicon Valley starts on the other part of Palo Alto, the town next door. It’s just really one road. But it’s physically separate, they can clearly understand this [separation]…So we saw where the line is drawn. And it’s important to have that line. Many people will tell you: ‘You know, you should stand with your feet in practice to be a good lecturer and vice versa; every company should do research.’ But my view is, no, it’s not right; one should understand your role and then cooperate.

Interviewer: That’s part of what I’m writing [about]. I’ve talked about a concept called ‘fundamental-applied’. Well, that’s what you’re doing. You’re doing fundamental, but you’re thinking of its application?

Prof. Q: Sure, ja. And we [academics] do a bit of consultation to know what’s going on. But we know our roles…
Professors Q, R and S had actually experienced what I then called ‘fundamental-applied’ research alongside pure applied research and, moreover, had seen how such use-oriented research can actually work (‘we saw the model’). They had seen how some of the engineering laboratories at MIT and Stanford developed high-quality basic research, always with an ‘eye out’ for its application. According to my emergent new perspective, this clearly was UIBR in terms of Stokes’s categorisation. At MIT and Stanford they also saw that, in order to prevent ‘drift’ downwards into consultancy work without any strong research components, you needed to ‘know your roles’, to have not only a physical separation across ‘the one road’ but also a social structural separation between university and industry. I had had no idea of these MIT–Stanford links during the first interviews at the Space Centre in 2000, but the second interview showed that the professors there had brought some of the ideas across the skies from America, and had planted them in the Space Lab of their university.

There had undoubtedly been a conscious theorisation by some of these professors of how they should undertake their research, particularly with regard to maintaining what Professor Q referred to as an ‘artificial wall’: a complex academic wall between UIBR and PAR (in the university Space Lab) and commercial technological development (in the science park industrial company). I therefore began to hypothesise that maintaining such a relative autonomy significantly helped to enhance the quality of the research work within this departmental research grouping comprising the network of professors. In particular, I wondered whether some of the modes of undertaking research seen by these professors at MIT and Stanford, and transferred to their own university, were central to the fact that this virtual centre was still flourishing at the time of the final interviews in 2007.

Again, therefore, a new perspective had emerged, leading to the need to address further issues and questions in the analysis of cases: How do the research leaders (and their co-researchers) in each of the 10 use-oriented Western Cape research groupings view and manage the ‘close’ relationships with industry and (sometimes) other societal groupings? Do their practices reflect the maintenance of some relative autonomy between their own academic mission of use-oriented research and the practical needs of ‘clients’? And, moreover, in their work do they consider that there is a significant ‘academic revolution/ transformation’ taking place in the way research is now being carried out internationally?

Towards a new theoretical framework

After the second phase of interviews, all the data that had been collected from the cases indicated that in seeking to carry out the ‘development’ third mission, Western Cape universities were part of a major new academic transformation in research, of the kind which a writer like Etzkowitz (and others such as Leydesdorff, Gibbons and Castells, but in different ways; see Chapter 3) felt was taking place at universities internationally.
It seemed also that at least a few of the case study professors, as in the Space Centre, were aware of, and were incorporating into their work, some of these international trends, while seeking to maintain a degree of autonomy in their use-oriented research from the more narrow demands of industry in particular. Moreover, it appeared that one could not fully grasp some of these new research processes unless one added Stokes’s (1997) concept of UIBR to Etzkowitz’s (and others’, as discussed in Chapters 2 and 3) analytical framework.

In summary, many signs pointed towards the validity of Etzkowitz’s concept of a ‘second academic revolution/transformation’. But, as a historical materialist, I considered that if such fundamental academic transformations were taking place internationally in the post-1970s period as highlighted by Etzkowitz, surely something big must also be taking place in the global political economy outside the universities? In other words, it is difficult to consider such an academic transformation happening independently of external socio-economic factors that were impacting massively on universities and shaping such changes.

Thus, after the interviews of 2005, I confronted a new question: Is a significant spreading of the features of a ‘second academic transformation’ across universities internationally after the 1970s, and also across the 10 Western Cape use-oriented cases, itself associated with a capitalist industrial revolution in the global economy?

When I came to the third phase of interviews in 2007, I was therefore exploring a much broader hypothesis at the core of the framework for the study: that symbiotically linked to all these major academic changes there has been a new (third) global capitalist industrial revolution taking place since the late 1970s.

In essence, I am hypothesising that this third capitalist industrial revolution, as schematically illustrated in Table i.1, is based on a ‘knowledge society’ in which the new technological regime of ICT, biotechnology, and other technologies that are evolving, is rooted in university-based scientific discoveries. Or, put another way, the post-1970s UIBR undertaken by universities – especially in the fields of physics, chemistry, biogenetics, etc. – is essential for the survival and success of capitalist TNCs within a competitive global economic system. I propose that it is this post-1970s ‘great transformation’, in which university knowledge is now essential for capitalist industry, that underlies the second academic transformation, and the related university mission of contributing to the economic development of society at large.
Table i.1 The three major industrial revolutions

<table>
<thead>
<tr>
<th>Capitalist industrial revolution</th>
<th>Major technologies ('technological regime')</th>
<th>Capitalist form of economic organisation</th>
<th>Associated academic transformation</th>
</tr>
</thead>
<tbody>
<tr>
<td>First revolution 1770s–80s (led by Britain)</td>
<td>Textile machinery, water power, etc. Later: steam engines, railways, etc.</td>
<td>Small family firm</td>
<td></td>
</tr>
<tr>
<td>Second revolution 1870s–80s (led by Germany)</td>
<td>Electricity, chemicals, steel, etc. Later: automobiles, synthetic materials, etc.</td>
<td>National shareholding corporation</td>
<td></td>
</tr>
<tr>
<td>Third revolution 1970s–80s (led by the USA)</td>
<td>ICT, biotechnology, nanotechnology, etc. Later: ?</td>
<td>TNC-cum-networks</td>
<td>Second academic transformation*</td>
</tr>
</tbody>
</table>

Note: * The first academic transformation of the 1800s, joining research to teaching, is not shown in this table because it did not play a fundamental role in the first or second industrial revolutions. I consider this further in Chapter 3.

I thus propose, as a central argument of my study, that what I have termed the third capitalist industrial revolution is producing as many fundamental changes as were seen in the first and second industrial revolutions or ‘great transformations’ of the previous approximately 100-year periods (1770s–1870s and 1870s–1970s), and that these changes involve the TNC-cum-networks, a type of entity that has emerged as the dominant new form of economic organisation in the twenty-first century.21 But the industrial changes that have been taking place since the 1970s are also symbiotically linked to university academic research. For example, the electronics on which the relatively new technology of ICT is based is inconceivable without theories of modern physics (including quantum mechanics) developed by university professors.22 Similarly, the biotechnology that has significantly enhanced this new technological regime since the 1980s would not have been possible without the biochemistry (including DNA theories) developed in leading research-intensive universities decades earlier. Thus I propose that a new type of research, UIBR rooted in advanced scientific theory, provides the essential foundations for the cutting-edge technologies of the third capitalist industrial revolution.

TNCs – as a prime agency for this great transformation – need UIBR not only to improve their competitive edge but also for their very survival; that is, the Schumpeterian perspective (noted earlier) on technological innovation seems to hold here. To sustain and increase their profits, I hypothesise that they seek UIBR where it is most strongly located: within the research centres and units, especially those of research-intensive universities. This suggests that there is also a symbiosis between the third capitalist industrial revolution and the UIBR research centres and network structures that have proliferated as a result of the second academic revolution. I argue in later chapters that larger and more mission-directed research groupings – such as the Model A or Model C centre types described above – are needed to sustain U–I research relations.
Finally, it might be useful to end this introductory theoretical discussion with some thoughts about the connections between the theory and my personal history that struck me during the third phase of interviews in 2007. These reflections linked, quite unexpectedly, the perspectives on the third industrial revolution/second academic transformation which I was developing at the time and the fact that I had experienced both electrical engineering (which I now view as part of the second industrial revolution) and electronic engineering (part of the third industrial revolution) while I was an electronic engineering undergraduate at the University of Cape Town (UCT) around 1970. In fact, these reflections directly connected with the idea of electronics research at universities as an important part of UIBR, a core concept I had taken on board at this stage in the research. As Table 1.1 indicates, electricity was an important technology that helped shape the second industrial revolution from the 1880s onward, while electronics linked to ICT has been a vital technology shaping the new industrial revolution that began in the 1970s and continues today. It appears to me now that our electrical engineering training was itself ‘divided’ by these two types of ‘electricity’. This was because our four-year academic programme at the end of the 1960s involved a division of the class, after a common first year, into what was known as ‘ElecEng A’ and ‘ElecEng B’. The ElecEng As studied what was called ‘heavy current electrical engineering’, focusing on electric motors and power supplies – electro-magnetic technologies with their roots in the second industrial revolution of electrical discoveries of the late nineteenth century. In contrast, my ElecEng B group studied ‘light current electrical engineering’, and we were viewed as ‘less practical’. We followed a significantly different path of study, joining the physics and mathematics students in their second-year classes and, in our third and fourth years, doing courses with the physics students, including quantum physics. I can now see that we were in effect being taught the basis of UIBR, focusing on electronics (especially transistors – linked also to early computer-based technology) and theoretical physics and applied mathematics – subject fields in which research would soon become linked to firms at the cutting edge of the third capitalist industrial revolution. These personal details provide an example of how the third capitalist industrial revolution and its new technological regime are deeply rooted in UIBR within universities, with cutting-edge technology derived from basic science theories. At our graduation in 1970, neither ElecEng Bs nor ElecEng As foresaw clearly the massive technological revolution that was soon to unfold. We ElecEng Bs were, though we did not realise it at the time, an advanced cohort being trained for this in the late 1960s, and would be in great demand when new U–I–G triple helix relations blossomed from the 1980s onwards in the USA and Europe. In contrast, the ‘heavy current electrical’ training of the ElecEng As was rooted in PAR, itself more empirically – rather than theoretically – driven. This cohort would still be much needed for industrial development, but did not work at the cutting edge of technological innovation.

Some of the crucial elements of the new capitalist industrial revolution after the 1970s, and their impact on universities, form the core of the story in the three
chapters that follow. The various hypotheses proposed by Etzkowitz in relation to his core concept of the second academic revolution will also be examined more closely and critically at the beginning of the next chapter. This introduction concludes with a brief guide to the organisation of the book, showing how the three parts form an integrated whole that addresses the main questions posed in the discussion above.

The organisation of the book

Table i.2 summarises the three-part structure of the book. There appears to be a neat linear division between the three parts, but it is important to stress that there is no tight separation, analytically, between them. For example, this Introduction has already shown how initial analysis of the case studies of Part 2 during the period after 2000 caused me to rethink the basic issues and perspectives, giving rise to new questions to be explored in Part 1. In the period 2005/06, at the time of the second phase of interviews, I focused on the international literature relating to the second academic transformation in symbiosis with a third capitalist industrial revolution, that is, the focus was on the theoretical work of Part 1. These emerging theoretical perspectives were then used in the analysis of the case material, especially after the third phase of interviews in 2007. There was thus a continuous to-and-fro movement between the theoretical and case study investigations presented in Parts 1 and 2. And then, as I began to focus on Part 3 after the third phase of interviews – drawing together the threads of the 11 cases – my analysis began to feed back into questions in Parts 1 and 2.

Table i.2 The structure of the book

<table>
<thead>
<tr>
<th>Part</th>
<th>Summary</th>
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<tr>
<td>1</td>
<td>Examination of the concept of a global second academic transformation in symbiosis with a third capitalist industrial revolution: empirical evidence, historical trends, theoretical issues (preceded by an introductory overview of emerging new issues and perspectives).</td>
</tr>
<tr>
<td>2</td>
<td>Case studies of 11 research groupings at universities in the Western Cape (preceded by an introductory discussion of the South African university research system).*</td>
</tr>
<tr>
<td>3</td>
<td>Drawing together the threads of the 11 case studies (with a concluding consideration of new concepts and new policy implications).</td>
</tr>
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</table>

Note: * The Introduction to Part 2 was co-authored with Michael Kahn of the Human Sciences Research Council, who was connected to the study after the second phase of the investigation (see Appendix 1).

Finally, I must note two other relevant points about my case study analysis. Firstly, especially after the second phase of interviews, I was effectively guided by what Burawoy (2004) has termed the ‘extended case study method’: developing broader theoretical and empirical insights from literature, in this context with reference to the wider international situation of universities and use-oriented research. One of his important points about case studies was thus put into practice, namely that while one does employ a method of ‘grounded theory’ (allowing some theoretical insights to ‘emerge’ from the data of the cases ‘on the ground’), one never simply derives theory
from the case material; instead, a vital element is to draw on existing relevant theory and broader empirical data from the literature, which can help to make sense of, or ‘speak to’, the cases.

Secondly, I was influenced by certain ideas about case study methods, such as those of Gomm, Hammersley and Foster (2000), who argue against the view that case study analysis is only about ‘in-depth, qualitative understanding of the specific case’. They argue instead that case study analysis, particularly through comparisons between cases, can also yield insights into general trends and patterns across the cases.26 In this way, by means of what was effectively a comparative case study method, I sought patterns of similarity and differences between the 11 cases.

Thus a set of interrelationships emerged across the parts of the book, giving rise to a complex but integrated whole methodologically. My hope is that this methodology can do justice to the original core research question posed in 2000: what are the major enhancing and inhibiting factors affecting university research centres and units of the Western Cape, in relation to their fulfilment of use-oriented research for wider societal constituencies? The concluding sections of the book will seek to deal with at least some key policy issues concerning the reforms needed in university research structures and administration to enhance such use-oriented research. In this way it is hoped that new policy discourses will emerge, not only in the Western Cape but in the South African university system as a whole, to confront some of the very serious problems that, as many of these case studies suggest, we are facing within our universities in relation to the research practices of UIBR and PAR.

Notes
1 This was the title of the original project proposal of 1999 (see Cooper 2003b). A funding grant for this first phase of the project was received from the International Development Research Centre (IDRC, Canada). See Appendix 1.
2 In Executive Summary of original funding grant proposal.
3 See Appendix 1 for a more comprehensive discussion of the research methods and design used during the case study research on the 11 Western Cape university research groupings.
4 As discussed in Chapter 3, in the Western Cape and internationally a wide and confusing set of terms is actually in use, including research ‘institutes’, ‘schools’ and ‘groups’. Because of the small sample size (approximately 10 cases were proposed for the original grant project), the sampling procedure did not initially distinguish between these two types of research groupings. In the end, the majority emerged as larger centre-type groupings, but I ensured that there were some smaller units as well to enable useful contrasts to be made between the two types (see case studies in Part 2 and also Appendix 1).
5 For example, as discussed in Chapter 3, Gibbons et al.’s (1994) ideas about the (old) Mode 1 versus the (new) Mode 2 research were being debated in the 1990s in South Africa.
6 At the time of the first phase of interviews in 2000, in the greater Cape Town area (including Stellenbosch) there were three universities (from which seven research groupings were selected) and two technikons (from which four research groupings were selected). After 2004, the two technikons (renamed universities of technology in 2003) began a merger
process to form the Cape Peninsula University of Technology. By the time of the final interviews, however, the merger process had not yet impacted in any significant way on the four technikon case studies. The structure of 11 cases from the five HEIs has therefore been retained throughout the study. (See details in Appendix 1.) The term ‘university’, unless otherwise specified, is used throughout the book to refer to both ‘universities’ and ‘universities of technology’ in South Africa.

Note, however, that whereas Etzkowitz tended to focus somewhat narrowly on the third mission as ‘economic development’, I viewed this third mission of ‘societal development’ in a broad framework that incorporated social, economic and cultural components.

This phase of the project (see Appendix 1), entitled ‘A follow-up study of eleven research centres and units at the universities of the Western Cape’, received a funding grant from the Knowledge Systems Group of the Human Sciences Research Council, under executive director Professor Michael Kahn. I was fortunate to have six months of sabbatical leave during this period during which I could conduct the research.

Each of the 11 cases analysed in Part 2 has been given a pseudonym linking it to its broad field of research (see also Appendix 2).

I am grateful to Professor Peter Weingart, who referred me to Stokes’s work at the time. The differences between PBR, UIBR and PAR will be more fully explored in Chapter 2, with reference to Figure 2.1.

Henceforth in this study I shall use the term ‘use-oriented’ (instead of ‘application-oriented’) to refer to UIBR and/or PAR (see also Figure 2.2 in Chapter 2 for further elaboration).

To avoid confusion between the terms first/second/third industrial revolution and Etzkowitz’s ideas about the first/second academic revolution, I shall from this point onwards use the term ‘academic transformation’ instead of ‘academic revolution’.

See Appendix 1 for a discussion of how the sample of cases was selected in part from proposals for case studies made by the senior directors of research administration at each of the Western Cape universities and technikons.

As will be explained more fully in Part 2, the category ‘virtual’ is used because of its much looser and more informal connotations than those associated with the conventional concept of a ‘centre’.

After coming across a reference to Etzkowitz’s book, I found that there was no copy in any Western Cape university library, and only one in South Africa – in the library of the Pretoria Technikon.

In this interview in early 2005, I still used the term ‘fundamental-applied’ because I had not yet fully taken on board Stokes’s idea of UIBR.

In later chapters, I refer to this idea of consultancy work with relatively few or no new knowledge components as ‘routine consultancy work’.

In this sense, I hold to a Marxist sociological position that major long-term changes in universities as part of the socio-cultural system of a society need to be understood in relation to major long-term changes in the political economy.

Here in some sense I follow Polanyi (1944), whose work many decades ago utilised the idea of a ‘great transformation’ to refer in part to what in Table i.1 I have designated as the post-1870s second capitalist industrial revolution.
It should be noted that the categories of Table i.1 are based on my conceptualisation of a capitalist ‘mode of production’, referred to earlier in the discussion: the social relations of production are here linked to the ‘capitalist form of organisation’ (family firm, TNC, etc.) and the social forces of production are referred to here as ‘technological regime’ for each major ‘industrial revolution’. These theoretical underpinnings of the table will be discussed more fully in relation to Table 3.1 in Chapter 3.

See also Chapter 3 for discussion of this point.

For example, with respect to a transistor, an understanding of the movement of electrons within a solid is based on the findings of quantum physics (I am indebted to Professor David Aschman of the Department of Physics at UCT for this point).

In 1970 I attained a BSc Elec Eng degree at UCT, before turning to the field of sociology for my further studies.

Some of my classmates went in exactly this direction, working in international corporations and/or universities, thereby leading electronic innovation in the 1980s and 1990s.

The contrast between the third industrial revolution and its link to more theory-driven science, and the second industrial revolution and its link to empirical science, is explored in Chapter 3.

Gomm et al. (2000: Chapter 5) warn, however, that one must be very tentative about such generalisations and inferred patterns of similarity or difference, with due regard to small sample sizes and possible confounding variables associated with the context surrounding each case. They also stress that such tentative propositions of general trends and patterns, derived from case study methods, are not based on statistical modes of assessment.
This chapter begins with a consideration of what might be called the ‘Etzkowitz set of hypotheses’ about universities and their new third mission, since the core elements of Etzkowitz’s approach will be central to my analysis of the Western Cape research groupings in Parts 2 and 3 of this work. The next section of the chapter examines certain empirical evidence – drawn especially from universities in the USA and Europe, and to a limited extent from elsewhere – supporting some of Etzkowitz’s hypotheses. While this is by no means a comprehensive review of the data, I will argue that there is indeed evidence that supports his central framing idea of a second academic revolution – taking place particularly within research-intensive universities of the northern countries of North America and Europe and, to some extent, in the global south, including Asia. The final section of the chapter contains a series of cautionary remarks about the nature and extent of this global academic transformation, and notes some of the ‘ideological baggage’ that accompanies a perspective of the triple helix which in essence affirms international capitalist industry at the heart of the U–I–G triad.

Etzkowitz’s hypotheses regarding a third university mission

Central propositions have been put forward by Henry Etzkowitz regarding the nature of what he calls the ‘second academic revolution’. He argues that this second academic transformation (as I prefer to call it) has been taking place internationally, especially since the 1980s, adding a ‘third mission’ – societal development – to the universities’ ‘second mission’ of research. This second mission had itself been added to the ‘first mission’ – teaching – during what he views as the first academic revolution in the 1800s.

Etzkowitz has outlined his ideas about the evolution of the third mission of universities – their contribution to what he terms the ‘socio-economic development’ of the broader society – in a wide range of works. One of the most interesting is *MIT and the Rise of Entrepreneurial Science* (2002), which is based on historical evidence, particularly of science and technology (S&T) departments at MIT and Stanford University. He argues that within these departments there was a very early institutionalisation of third mission practices, linking university research to industry during the first half of the twentieth century. (These arguments are considered in some detail in Chapter 2 of this book.) Older practices of the first mission (teaching) and the second mission (research) were intermingled with
new third mission practices at MIT and Stanford well before the 1980s, when the third mission's contribution to the economy began to be consolidated across other research-intensive universities in the USA.

On the first page of his book, Etzkowitz puts forward his core thesis that MIT is the embodiment of all three missions, having become a new academic model that displaced 'pure science' Harvard as the academic exemplar of the two 'traditional' missions of teaching and research:

The MIT model, combining basic research and teaching with industrial innovation, is displacing Harvard as the academic exemplar. Until quite recently, pursuing the 'endless frontier' of basic research was the primary ideological justification of elite US academic institutions. Harvard University was the model, with numerous schools identifying themselves as the 'Harvard' of their respective regions. Such claims are seldom heard anymore. With an entrepreneurial mode increasingly followed at Harvard, and at academic institutions that model themselves upon it, the predictions that MIT would eventually conform to the traditional US research university mode has [sic] been disconfirmed. Instead, the reverse process has occurred as liberal arts research universities adopt a mission closer to the 'land grant' tradition of regional economic development, MIT's founding purpose and historical forte. (Etzkowitz 2002: 1)

The final page of Etzkowitz's (2002: 150) MIT book provides what is probably the most succinct outline of the major hypotheses that have been embedded in his works for nearly two decades. Each hypothesis quoted here is followed by brief comments to set the stage for extensive discussion and questioning later.

Hypothesis 1 is that scientific knowledge is becoming the basis for economic competitiveness in the new global economy: 'As the production of scientific knowledge has been transformed into an economic enterprise, the economy has also been transformed, since it increasingly relies on an epistemological base. Intellectual property is becoming as important as financial capital as the basis of future economic growth...'.

Arising from this, it can be argued that academic knowledge is becoming a form of 'capital' and, in the form of intellectual property (IP), needs 'protection rights'. Thus, issues concerning university IP, in the form of patents and licensing and university technology transfer offices (TTOs), become important for academics.

Hypothesis 2 is that universities are becoming a central (economic) institution of society: 'As the universities' involvement in the capitalization of knowledge increases, their position in society is transformed from a secondary to a primary institution.'

Viewed in another way, it might be added that for over 100 years universities have played an important economic role in the production of graduates, who are needed by national economies (e.g. engineers, accountants, chemists, urban planners, social workers). But in recent decades the university's research production has become as
important as its role as a generator of graduates for the new global ‘knowledge-based economy’ (Leydesdorff 2006).  

Hypothesis 3 formulates this in a slightly different way, stating that the three missions of a university working in unity can provide this institution with a unique new, powerful role in the knowledge society: ‘The university’s unique status as a teaching, research and economic development enterprise, whose traditional and new roles reinforce each other, places it in a central position in the new economy.’

This is linked by Etzkowitz to broader arguments (discussed in Chapter 2) about the traditional missions of basic research and teaching: if these can be ‘fused’ through creative synergy with the third mission (economic innovation), then universities are in an excellent position to play a creative and vital role in the new knowledge-based economy.

Hypothesis 4 states that a triple helix of U–I–G research relationships is emerging as vital for the economic development of the knowledge society: ‘Rather than being suborned to either industry or government, the university is emerging as an influential actor and equal partner in an innovation, promotion and industrial policy regime, the “triple helix” of university–industry–government relations.’

Among the ideas embedded here are that universities are becoming crucial players in relation to research coordination between themselves, industry and government, and that such a U–I–G mode of research enhancement is a vital policy component of any NSI for economic development.

Hypothesis 5 asserts that it is possible to consolidate a new academic ethic that combines, in creative tension, both fundamental and applied research: ‘An entrepreneurial academic ethos that combines an interest in fundamental discovery with application is emerging as new and old academic missions persist in tension.’

Although I consider Stokes’s (1997) concept of UIBR (see Chapter 2) as much more theoretically precise than Etzkowitz’s idea here of combining ‘an interest in fundamental discovery with application’, the latter nevertheless points in the same broad direction as Stokes’s concept.

Hypothesis 6 affirms the importance of research-intensive universities in terms not only of their national (and international) economic development role, but also of their regional role: ‘The university’s emergence as a participant in economic development has not only changed the nature of the relationship between industry and the university but has also made the national university a significant regional actor.’

This hypothesis is vital: it expresses the idea that, when a university takes on a third mission of economic development, its research (and teaching) activities can play an economic role in regional as well as national development. It also implicitly opens the door to a broader concept of the socio-economic–cultural role of universities, embedding the ‘socio-cultural’ within the idea of the third mission which Etzkowitz views primarily as an economic mission (especially for MIT). Such considerations also enable the narrow triple helix of U–I–G relations to be broadened to include a
consideration of U–CS relations. These U–CS linkages are considered in Part 2 in relation to a few of the Western Cape case studies, in which I examine the economic, social and cultural roles of the university.

This brief sketch of the Etzkowitz hypotheses has created a framework for consideration of the issues raised in the sections and chapters that follow. It should be clear that these propositions need elaboration, refinement, altering, or even rejection at times. They need, moreover, to be contextualised within specific and diverse societies – not just those of the far more knowledge-based economies of the north, but also those of less developed economies like South Africa.

To explore this question of the second academic transformation further, I turn now to evidence gleaned from diverse studies, with particular reference to universities in the USA and Europe. The aim here is not to undertake a comprehensive review of the available data but simply to examine selected statistical data, together with some case study material, in order to support the following propositions:

- Major research-intensive universities – especially in the USA and Europe, but also in some other regions – experienced substantial internal transformations in the last quarter of the twentieth century.
- Such transformations are clearly linked to a new mission of the university – as an institution having a much greater role to play in the knowledge-based economy.
- Much more than previously, capitalist industry (in terms of its need for innovation and development) requires knowledge outputs from universities. This is linked to the fact that government is playing a greater supportive and coordinating role in enhancing what is called a national (and supranational) system of innovation. Nonetheless, in countries like South Africa the issue of whether and how the benefits of research-led industrial innovation might ‘trickle down’ to alleviate the conditions of the mass of poor people – who are largely disconnected from the U–I–G triple helix – needs much more critical debate, particularly with reference to the Western Cape case study material.

Some pointers to the ‘new university mission’

Certain quantitative and qualitative pointers to the third mission are discussed in the following subsections, with reference to the USA and Europe, and then briefly to some other countries.

Universities in the USA

Until quite recently most academic scientists and research universities abstained from commercializing research…[but] it is now becoming more common for teachers to exploit knowledge themselves and for administrative arms of the university to assist them. The transfer of technology has been accepted as an administrative function of research universities even as publication of research was earlier accepted as a responsibility of faculty members. (Etzkowitz 2003: 115)
If this characterisation of changing trends in academic research is accepted, a question arises: how widespread has this second academic transformation become – especially in the USA, the global knowledge-economy leader – in the terms conceptualised by Etzkowitz and others, with their focus on ‘commercialising research’ within triple helix relations?

Morgan and Strickland (2001: 113–115) provide some interesting overview statistics for American U–I research relations during the last two decades of the twentieth century – what I view as the ‘take-off’ period for the second academic transformation. They show that by 1998, American university-held patents had increased to more than six times the 1982 figure; between 1981 and 1995 there was a more than twofold rise in the percentage of papers co-authored by university and industry personnel; the number of citations of university papers on the front pages of industrial patents rose from 49 per cent to 55 per cent between 1988 and 1996; and since 1980 there had been a substantial growth in university equity investments as a mechanism for commercialising IP through university-led spin-off companies, shares in companies licensing university IP, etc. Morgan and Strickland also refer to a study by Slaughter and Leslie (1997: 5–6). These authors found that, although before 1980 biology had been seen primarily as basic science, by the mid-1980s most full professors of molecular biology in the USA held equity positions in biotechnology spin-off companies selling products to corporations, and were on national advisory boards for corporations with biotechnology products.

Colyvas (2007) has produced a fascinating study of how world-renowned professors in a biological field of research at Stanford University in the 1970s faced complex situations of ‘creative tension’ between their commitments to basic science ethics and their new applied science missions created by biotech companies seeking access to their research findings. Her research shows that between 1954 and 1967 formal technology transfer procedures at Stanford were minimal, but they began to grow after the establishment of an office of technology licensing (OTL) in 1968. The work of this office not only included matters such as the licensing of academic patents, but also focused on building relationships with companies in a general way. Her case study of a life science department in the Stanford Medical School showed that in 1970 there was only one invention disclosure by this department, while in 1980 there were nine, with 40 overall during the period 1970–82 (Colyvas 2007: 460). Patenting and licensing for this particular department played a major role in the definition and consolidation of the U–I practices of this university’s OTL. Between 1970 and 1982, invention disclosures from one of the labs of this department garnered more than US$1.8 million in royalties (Colyvas 2007: 463), while another lab of the same department yielded around US$2.3 million by 1982, with these inventions continuing to be lucrative through the late 1990s (2007: 471). In her conclusion, Colyvas notes that over the 33-year period from the establishment of the OTL in 1968 until 2000, two of the top three revenue-generating inventions at Stanford were life sciences disclosures. This highlights the fact that biotechnology was in certain respects at the leading edge of the academic transformation at American universities.
and internationally. This is explored theoretically in Chapter 3 with respect to the ‘new technological regime’ of the third capitalist industrial revolution.7

Drawing on evidence from this and other studies, Colyvas argues that ‘prior to the 1980s, few U.S. universities were involved in technology licensing, and university patenting was modest, although increasing’ (2007: 457). Pointers in this direction also come from Etzkowitz (2003: 118), who examines the emergence of American university TTOs, which increased in number from only 25 in 1980 to over 200 in 2001. This growth was linked to the rise of the USA’s Association of University Technology Managers, which in turn helped in the development of its European counterpart, the Association of European Science and Technology Transfer Professionals. This supports the idea that TTOs on American campuses – an important embodiment of the third mission – have become institutionalised as normal administrative activities, especially at the research-intensive universities.

The findings on the increasing association of research-intensive universities with patenting and licensing processes (i.e. their increasing participation in the second academic transformation) can be linked to a finding reported by Morgan and Strickland (2001). In a survey of engineering academic staff at the 200 leading American universities (where almost all academic engineering research is conducted), they found that the 100 least research-intensive engineering schools were more likely to be oriented towards applied research and development (R&D) than the top 20 research-intensive schools – yet the latter were ‘more likely to produce patents, licences and invention disclosures as outcomes of their research’ (Morgan & Strickland 2001: 115).

This relates to an interesting hypothesis – explored in the Western Cape case studies in Part 2 – that distinguished basic research academics are more likely to become oriented towards UIBR (which in turn produces more lucrative patents and licensing), while ‘lower-level’ academic researchers lean more towards PAR. Thus, research-intensive universities appear more likely to be involved in cutting-edge discoveries valued by the leading sectors of industry, rather than becoming involved in more standard PAR and development work.

A qualitative indicator of a major academic transformation might also be sought in the modes in which academics undertake their research. The literature reviewed in Chapter 3 points, I suggest, to a shift internationally from a small research unit (the professor and a few post-docs and PhDs) towards a larger centre encompassing a research director and subgroups of senior researchers and postgraduates, underpinned by a fairly extensive administrative infrastructure. The idea of ‘research networks of excellence’ (NoEs), also reviewed in Chapter 3, suggests inter-institutional research collaboration spreading across the units and centres of different universities and research organisations. Some pointers are mentioned here.

In the USA there do appear to be such shifts in the modes of research organisation into larger centres, with more networking between research groupings within and across institutions. For example, numerous studies have been undertaken over
more than a decade by Bozeman and his colleagues of laboratories, research centres and diverse research groupings at universities and other organisations (see Crow & Bozeman 1998, on laboratories; Bozeman & Boardman 2003, on research centres; and Corley et al. 2006, on multi-institutional research collaborations). Many of their findings suggest significant changes in modes of research organisation, and in accompanying tensions (which they term ‘role strain’) within academia in the USA (Boardman & Bozeman 2007). Importantly, the 1980s seems to have been a period when significant transformations in modes of American research organisation were set in motion by the federal government, as summarised by Corley et al.:

In the U.S. in the 1980s, a series of technology transfer policies (Bayh-Dole Act, Stevenson-Wydler Act, and Cooperative Research Act) increased R&D interaction among researchers throughout universities, federal laboratories, and other research organizations. In particular, technology programmes such as the Advanced Technology Program (ATP) require inter-institutional collaboration for funding and research. Further, some National Science Foundation programs (Engineering Research Centres [ERCs], Science and Technology Centres [STCs], Nanoscience and Technology Centres [NTCs], Industry/University Cooperative Research Centres [IUCRCs]) require inter-institutional collaboration. (2006: 975)

Note that a major focus of post-1980 research funding initiatives in the USA – linked to the enhancement of the third university mission – has been on technology transfer, which itself has been initiated through various modes of inter-institutional collaboration and networking. In addition, the modes of research centre organisation – ERCs, STCs, IUCRCs, all established since the 1980s, and NTCs of later origin – have been stimulated ‘from above’ by government through its National Research Foundation and by other means. Corley et al. therefore assert that ‘U.S. science and technology policy has moved from the decentralized support of small, investigator-initiated research projects…’ (2006: 975), which points to a shift away from stand-alone, professor-led research units in small labs. In a footnote to this assertion, Corley et al. add the telling comment that ‘[in] the area of biotechnology alone, for example, Hagedoorn (1993) demonstrates that from 1980 to 1988 the biotechnology field generated significantly more inter-institutional research alliances than did any other field of research’ (2006: 976).

Hagedoorn’s (1993) findings are important because they point to the fact that the biosciences – highlighted earlier as one of the cutting-edge fields for the second academic transformation in the USA in the 1980s – were generating new modes of research organisation ‘from below’: academics themselves were developing new modes of organising their research activities in terms of networks of inter-institutional research alliances. There seem, then, to be thrusts from above (for example by governments) as well as from below (for example by the researchers themselves), giving rise to a second academic transformation that includes new modes of research organisation. This issue is explored in the Western Cape case studies in Part 2.
While it is true that much of the literature on American universities highlights biotechnology and ICT as leading the academic transformation in the 1980s, I will argue throughout this book that a very broad range of other fields (including the social sciences) have also begun to shift in the direction of a third mission. For example, in Morgan and Strickland’s (2001: 117, Table 5) 1997 national US mail questionnaire survey of nearly 1 000 biology, chemistry and physics professors, just under 50 per cent of physicists responding stated that their research outputs had become more oriented towards commercial products or processes during the course of their academic careers, with the figure rising to around 55 per cent for chemists and just over 60 per cent for biologists. Such data point to a wide penetration of the third mission, at least in the natural sciences, although the traditional applied fields like engineering were still in the lead, alongside the newer fields of biochemistry and ICT.

Roger Geiger, a leading historian of American research-intensive universities with two books spanning the 100-year period from the late 1880s to the late 1980s,9 came to the important conclusion that, following the 1960s boom in federal research funding, ‘the American university research system responded to the stagnation in federal research funding [in the 1970s] by gradually forming more research relationships with other sponsors – by conducting research of more proximate utility to society [in the 1980s]’ (Geiger 1990: 15). By the end of the 1980s Geiger was already able to claim from his data that during the 1980s ‘the fastest growing component of the university research economy [was] industry-sponsored research’ (1990: 15).

In perhaps the most important synthesis thus far of American university research data for the recent period, Geiger’s (2004) subsequent study of American research universities, Knowledge and Money, brings the story up to the early 2000s. His analysis provides a set of extremely valuable insights into what happened during the last quarter of the twentieth century. The book begins with a statement of one of his basic findings: ‘Only around 1980…did a fundamental re-orientation begin to take place. [American universities] embraced the mission of contributing to the economy, especially by forging links with private industry’ (Geiger 2004: 3).

He suggests that three major reasons for the increased linking of significant fields of academic research to economic development in the 1980s were: i) a widespread perception of a crisis in American economic competitiveness; ii) the emergence of biotechnology as the new cutting edge of industrial innovation; and iii) the perception by universities of increased revenue to be derived from patenting, from university-linked research parks, etc. Towards the end of the book he reiterates a core argument: ‘In the decades of the 1980s and 1990s, American universities literally transformed themselves…they emphasised generic fields of research,10 sought to recruit companies into university ventures, and made forays into the private economy by commercializing their own discoveries’ (Geiger 2004: 230).

In Knowledge and Money one of his most fascinating areas of analysis revolves around his argument about the vital importance of medical science within the
research universities of the USA, and how it has increasingly become connected to industry (e.g. pharmaceuticals). Already by the late 1950s – with the establishment of the National Institutes of Health (NIH) after the Second World War as a separate federal funding agency for the health sciences – medical science research (including research in medical schools affiliated to universities) had, he shows, grown enormously within the American university system. In addition, NIH funding became even more central to this system in the last quarter of the twentieth century: ‘From the late 1970s to the late 1990s it grew from 47 percent to 57 percent of federal support for academic research’ (Geiger 2004: 297).

A major factor responsible for this growth beyond 50 per cent was the rise in importance in the 1980s of the revolutions in molecular biology and genomics, themselves often closely linked to medical research and the health science industries (Geiger 2004: 144). In fact, Geiger suggests that ‘the doubling of NIH budgets from 1997 to 2003 provided an enormous impetus to biomedical research’ (2004: 152).

Just as important as this de facto ‘triple helix’ of U–I–G relations in medical research, he argues, has been the fact that much of the research in molecular biology now blurs the distinction between ‘pure’ research and ‘applied’ research. Or, as he puts it, there is a ‘direct connection between basic research in molecular biology and potential commercial applications’ (Geiger 2004: 215).

This exemplification of Stokes's idea of UIBR in terms of its direct links in molecular biology to industrial applications will be further explored in Chapter 2. However, it is important here to note another insight of Geiger's into this research revolution associated with biotechnology: ‘…molecular biology became Big Science, or Big Biology, performed with teams of researchers in multiple laboratories, equipped with costly, sophisticated instruments’ (Geiger 2004: 153).

This statement links to what is perhaps Geiger's most interesting argument in his study: the fact that the last quarter of the twentieth century has seen a significant expansion of what he calls organised research units (ORUs), which now span a wide range of research fields in the natural and engineering sciences, and even the social sciences. These larger units or centres, often separate from what he views as the ‘academic core’ – the disciplinary-departmental base of the universities – embody relatively ‘bigger science’ and have mushroomed in multiple forms, often alongside rather than inside the ‘departmental core’ across the universities. Moreover, according to his data, on the one hand tenured academic staff numbers overall within the departmental core did not show any substantial increase during the 1980–2000 period; on the other hand, a major source of growth in research staff numbers during this period (including in areas other than medical research) was in ORUs, primarily outside academic departments. Nonetheless, he shows that at some universities there is actually a close link between the ORUs and the academic staff within a department, while at other universities there is a disjuncture (Geiger 2004: 162–164). In other words, across the American university system there have emerged complex and varied relationships between the staff of academic departments and
ORU staff – a phenomenon that will be examined in the various case studies of Western Cape research centres and units in Part 2.

Geiger asserts that in no way should one view research in the departmental ‘core’ as declining. In fact, he argues that despite relatively weak growth in the number of tenured appointments, in terms of research output there was significant growth. Yet at the same time it was clear that ‘[ORUs] have proliferated, and, where this figure is reported, they typically perform more than half of an institution’s research’ (Geiger 2004: 172). This is also linked to another trend his investigations encountered: an increasing separation between research (the second mission, according to Etzkowitz) and teaching (the first mission). According to Geiger, this has been occurring in the core, where academics within departments have increasingly been using research funds – often linked to industry – to attain ‘buy-outs’, especially from undergraduate teaching. But the growth of ORUs has also significantly contributed to this. In essence, therefore, the 1980–2000 period saw a massive expansion of university research, often symbiotically linked to the third mission of economic development, and this ‘could not have happened if research were solely a joint product with teaching; more than ever it has become an autonomous role and a separate output’ (Geiger 2004: 254).

This selection of quantitative and qualitative indicators from the USA has provided material for a rich set of questions and issues linked explicitly and implicitly to Etzkowitz’s hypotheses outlined at the beginning of the chapter, which will be considered in greater depth historically and theoretically in the next two chapters. This chapter turns now to a discussion of pointers towards a second academic transformation in Europe, which initially lagged a little behind the USA, with ‘take-off’ occurring in the 1990s.

Universities in Europe

The evidence emerging from universities in Europe suggests that, from the late 1980s, a second academic transformation – centred on the growth of U–I research linkages – began to take root there too.

Morgan and Strickland (2001: 114) cite a study (Sequira & Martin 1997) that found that, by the late 1990s, 52 per cent of HEIs in the UK had created partially or wholly owned companies to exploit their research. Another UK study by the latter authors also found convincing evidence in the mid-1990s of cultural change in physics departments, which were more inclined to conduct research with results likely to be of benefit to industry.

A fascinating study of Oxford University spin-off companies (Smith & Ho 2006) shows how important components of a second academic transformation have clearly taken root, in ways one would never have expected three decades ago, in this heart of British academia, which has been historically driven by a ‘curiosity-oriented’ ethic of basic research. The investigation in 2005 by Smith and Ho involved a case study in Oxfordshire, an English county with a rapidly growing high-tech economy, where
they focused on the spin-off companies of ‘Oxfordshire’s three universities and seven national/international research laboratories (the research base) [which] are located in one of Europe’s most innovative regions’ (Smith & Ho 2006: 1557).11

Smith and Ho found that, in 2005, 80 per cent of the 114 Oxfordshire spin-off companies12 had been formed by Oxford University staff, with very few coming from the other two universities, and the rest from the seven laboratories. They point out that the number of Oxford University companies was close to that of Cambridge University at that time, and that Oxford University was generating three times as many spin-offs as the UK average of two university spin-offs per year (Smith & Ho 2006: 1559). Oxford’s record at that time was bettered in Europe only by Sweden’s Chalmers University of Technology, which by 1995 had already ‘spun out’ over 200, and internationally by world leader Stanford University, which had over 1 000 spin-offs in the Silicon Valley area (Smith & Ho 2006: 1561).

Interestingly, therefore, as already hinted at earlier, it is the elite research universities – in this case the Oxbridge universities of the UK – which have been providing the academic lead to high-tech industry in the UK. It is also worth noting that 40 per cent of the 114 spin-offs were biomedical (biotech and pharmaceuticals) – again similar to Cambridge University data – while information technology (IT) firms made up another 29 per cent, with a range of other S&T fields comprising the remainder.13 The findings thus show that biomedical and IT research was at the forefront of the third mission with regard to U–I–G relationships, at least in the UK.

Also important is the historical context of the spin-off companies emerging from Oxford University. Smith and Ho found that nearly two-thirds of the 114 firms emerged only after 1993 (2006: 1561). They suggest that Labour Party government initiatives from 1997 were an important factor in this increase, linked for example to the 1998 Higher Education Reach Out to Business and the Community and the 1999 University Science Enterprise Centres. But they note that, like the ‘Cambridge Phenomenon’ of spin-offs in the 1980s (Segal, Quince & Partners 1985), over 30 firms had already emerged from Oxford University by 1987, with a number of the 114 dating back to before 1976 (Smith & Ho 2006: 1161–1162). At the same time, they suggest that a turning point was reached for Oxford University around 1997, when Isis Innovation, the university’s technology transfer corporation (which had been established in 1988), came under the leadership of Dr Tim Cook, a successful business entrepreneur and ‘business angel’ (mentor of start-up firms). Isis became a major factor in Oxford University’s post-1998 growth of spin-offs in the Oxfordshire region, with Isis itself having the largest number of commercialisation staff of any UK university (Smith & Ho 2006: 1559).

In summary, therefore, the case of research-intensive Oxford University clearly shows a heightened involvement since the 1990s in a third mission and triple helix U–I–G relationships. And although biomedical and IT fields predominate, a culture of the second academic transformation – while not uncontested – does seem to have been carried forward more broadly in significant ways by this traditional university, alongside its partner at Cambridge.
Case study evidence from Sweden – internationally one of the most extensive welfare-state social democracies – also suggests that American trends reflecting a second academic transformation are spreading across Europe, with a shift towards industry-oriented research and funding as the most striking indicator. In a valuable article, Jacob et al. (2003) summarised some of the core changes in the Swedish research landscape during the 1990s. In the pre-1990 period, they argue, Swedish research ‘was dominated by university-based basic research with a few independent state-funded industrial research institutes’ (Jacob et al. 2003: 1557). The election of a Conservative Party government in the early 1990s served as a catalyst for change from ‘what may be described as a science system to an innovation system, with the universities being accorded the central position. The social democratic government that succeeded the conservatives four years later continued this transformation process’ (Jacob et al. 2003: 1557). Although it is not possible to explore the details here, in their insightful analysis it emerges how a series of initiatives were taken during the 1990s to create an infrastructure for the commercialisation of university-based research. These Swedish initiatives, which in essence fall under the umbrella of the second academic transformation, included the consolidation of a previously fragmented research council system into five large research councils; the setting up in 1994 of ‘wage earner foundations’ to fund additional research, with funding derived from interest accrued from capital bases invested on the stock market; and a redefinition of ‘strategic research’ from its previous meaning of research that has ‘some long term future potential for application’ to a more focused meaning of ‘research that has the approval and/or collaboration of specific target groups’ (Jacob et al. 2003: 1557). In 1997 the redefined concept was linked to a government amendment to the Swedish university charter to include explicitly what was termed a ‘third task’ in addition to teaching and research: ‘This third task states explicitly that universities now have an obligation to inform the public about their research and to actively co-operate with other actors in the society to decide research goals and problems’ (Jacob et al. 2003: 1557). Jacob et al. suggest, too, that although the new task was not further specified or defined, a dominant interpretation (though hotly debated and disputed nationally) was that the third task was ‘mainly about the commercialization of academic research’ (2003: 1557).

The insights provided by Jacob et al. (2003) thus suggest an academic transformation of a deep nature unfolding in the 1990s within this traditional Nordic social democracy. It is useful to look further at the ‘higher’ level of the European Union (EU) over the past two decades, to see whether there are pointers to the existence, at this supranational level, of a second academic transformation associated with U–I–G relations.

The evidence shows that changes have certainly been taking place within the EU, especially since the late 1990s, in assisting universities with the development of a third mission. It might even be suggested, from the data presented below, that if one seeks direct evidence of an emergent third mission for universities, transformations at the level of EU research policies are the clearest source of such evidence. Perhaps
the most dramatic element has been the ‘Lisbon strategy’, declared at the European Summit of 2000:

In March 2000, Heads of State and Government set the European Union (EU) the goal of becoming by 2010 ‘the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion’ (*ERA News*). This goal came to be referred to as the ‘Lisbon strategy’ and was followed shortly by the ‘Barcelona objective’ according to which ‘investment in European research and development must be increased with the aim of approaching 3% of GDP by 2010’ (*ERA News, 2000*). (Luukkonen et al. 2006: 239)

In this quotation it is not only the concrete goals of increasing R&D to 3 per cent of GDP and of the EU ‘outcompeting’ the economies of even the USA and Japan that are important. The quotation also clearly reflects what I term the mindset of NSI. The NSI perspective has, since the 1990s, increasingly penetrated official EU thinking about economic growth being linked to innovation in S&T. Concepts such as ‘knowledge-based economy’ – which through ‘dynamic growth’ will also ‘deliver jobs’ and ‘social cohesion’ across the EU countries – loom large in this discourse, as is evident from this quotation, which reflects an ‘NSI ideological framework’ that is explored more fully in later chapters.

Also important is the reference to the European Research Area (ERA) in *ERA News*. Alongside the Lisbon/Barcelona objectives, the ERA is linked to the strategies of the EU framework programmes (FPs), another vital element of EU transformations related to the third mission of universities. Each FP of the EU has involved billions of euros in funding R&D across member states. The first, FP1, was initiated in the mid-1980s, and FP7 is now under way for 2007–13. ‘The [European] Community Framework Programmes for Research and Technological Development are multi-annual programmes in support of European S&T and industrial competitiveness. They mainly provide support marked by “European added value” for research projects by trans-national and mixed-actor (firms, universities, research institutes) consortia’ (Delanghe & Muldur 2007: 171).

The main rationale for FP1 ‘was based on the perception of a technology gap between the EU and its major competitors’ (Delanghe & Muldur 2007: 171), at a time when thinking about the knowledge economy was just beginning to emerge in the EU after some years of S&T innovation in the USA. According to Delanghe and Muldur, the central goal of FP2 (1987–91) was ‘to strengthen the research base of European industry in response to fierce Japanese competition’ (2007: 171). Then, a decade later, initiated in the context of the Lisbon/Barcelona strategies, ‘FP6 (2002–2006) was designed to help build the European Research Area’ (Delanghe & Muldur 2007: 171).

It is important to grasp the link in EU philosophy between the Lisbon/Barcelona strategies (EU economic competitiveness) and the ERA strategy of building ‘research networks’, which was taking shape just after the turn of the millennium. This
construction of network modes of research is, I have already suggested, an important new component of the second academic transformation.

For example, the ERA strategy included the FP6 launch of a network of excellence (NoE) initiative. As Luukkonen et al. observe with respect to creating networks of researchers across the EU countries:

In an attempt to deal with the perceived fragmentation of European level research, the [European] Commission introduced the concept of the European Research Area (ERA) [in 2000] aiming to create an ‘internal market’, an area of free movement of knowledge, researchers and technology, with the aim of increasing cooperation, stimulating competition [between researchers] and achieving a better allocation of [research] resources [cited from EU Commission website]. Following that, the networks of excellence (NoEs) were launched by the Sixth Framework Programme of the EU as one of the many initiatives aiming to support and promote the ERA. (2006: 239)

The ERA had already been enhanced by the research consortia collaborations of the FP5 initiative of 1998–2002, with almost 180 000 collaborative research links being established (Delanghe & Muldur 2007: 175). The initiative of NoEs in FP6, which followed in 2002, had two main objectives: to increase and broaden research excellence, and to promote the integration of research performers into a ‘common Europe’, mainly through the creation of greater critical mass in research projects (Luukkonen et al. 2006: 240). FP6 sought to achieve such critical mass within each NoE by stressing even more strongly the collaboration requirements of ‘multi-actors’ (mainly firms, universities and research institutes) and ‘transnational consortia’ (research groupings from numerous EU states). Most research projects of NoEs for FP6 were thus more ‘mission-oriented’ and larger (in both funding and personnel) than those of previous FPs. Importantly, universities and non-university research institutes were now much more dominant than firms and corporations (Delanghe & Muldur 2007: 176).17

Very significant funding and goals for S&T research thus came to the EU through FP6: the average number of researchers per project was 14 (it had been seven for FP5); the average number of member states per project was seven (four for FP5); and the average funding per project was €4.3 million (€1.4 for FP5) (Delanghe & Muldur 2007: 175, Table 3). Moreover, with FP7 for 2007–13, the total research budget reached a level of around €50 billion – by far the largest budget ever – with the EU budget amount dedicated to research having risen from 2.4 per cent in 1988 to 4.3 per cent at the end of FP6 (Delanghe & Muldur 2007: 172).

There has clearly been systemic thinking by EU officials concerning the building of NSIs across the ERA. In essence, the philosophy is that, to ensure the future economic competitiveness of Europe, research structures need to be transformed. This would encompass:

• the coordination and integration of projects across a previously fragmented Europe
  in terms of diverse research structures and missions (i.e. building an ERA);
• multi-annual research projects amounting to billions of euros, overseen by a supranational state system, that is, a ‘transnational government’, the European Commission;
• bringing together firms (industry) with various academic researcher groups in university and non-university institutions, that is, building new and larger U–I–G research structures such as NoEs.

A third element, following the Lisbon/Barcelona strategies and the ERA/NoEs of FP6, was the incorporation into FP7 of ‘risky frontier research [which] will be supported through the European Research Council’ (Delanghe & Muldur 2007: 176). The term ‘frontier research’ refers to research that is even less ‘applied’ than ‘strategic research’. It incorporates something close to what has already been referred to as UIBR and includes PBR.

Linked to frontier research has been the establishment of an EU-wide European Research Council – a remarkable step forward. The European Research Council was established in 2005 to fund ‘frontier’, or more basic, research. The EU also set up a Scientific Council (advisory board) of the European Research Council, an independent body consisting of 22 leading European scientists, including in 2006 academics such as Manuel Castells and Helga Nowotny. This Scientific Council was expected to give legitimacy and functionality to the European Research Council by acting as an independent advisory body ‘to ensure the quality and autonomy of scientific judgment’ with respect to ‘excellent European science and scholarship, as assessed by peer review’ (Scientific Council of the European Research Council 2005).

Why this element of pure research, when from FP1 to FP6 there had been a much greater stress on application-oriented research? In part this was due to an emerging analysis of the vital role of basic science by many of the academics who had played an important part in establishing the idea of NSIs, which had influenced the EU through the FPs.18 Gronbaek argues, for example, that Pavitt (2000), a member of this informal academic group, produced an influential ‘radical proposal’ in 2000, arguing for a European Research Council-type of funding agency that would focus on ‘scientific excellence at European level and in doing so also stimulate industrial innovation’ (Gronbaek 2003: 396).

Pavitt’s linking of basic science excellence with industrial innovation and his contestation of the idea of the ‘European paradox’ – held by many adherents of the FPs – were supported by Giovanni Dosi and others (Dosi et al. 2006). The ‘paradox’ claims that EU countries play a leading global role in terms of top-level scientific output, but lag behind [the USA] in the ability of converting this strength into wealth-generating innovations’ (Dosi et al. 2006: 1450). Dosi et al., however, provided very clear evidence for their argument that Europe was weaker than the USA in terms of both academic output (for example, peer review publications per researcher) and industrial innovation (for example, innovative outputs like patents, etc.). Their conclusion was that Europe needed a dual strategy to enhance its academic research (what they termed ‘frontier research’) and at the same time deal
with what they termed ‘structural weaknesses of European corporations and science-industry interaction’ (Dosi et al. 2006: 1458).

One of Dosi et al.’s recommendations was to ‘increase support for high quality basic science, through agile [European] institutions like the American National Science Foundation (NSF), and relying on world-class peer-review’ (2006: 1461). This was in effect taken up from 2006 with the new European Research Council initiatives in frontier science research enhancement.

In conclusion, the review of EU research policies presented above suggests a self-conscious attempt, through the FPs of research enhancement, to achieve significant components of a second academic transformation/third mission across universities and other research institutions of Europe. This has involved an emphasis on a trans-European vision of global leadership in the knowledge economy, linked to massive research funding and associated after 2000 with development of the ERA and NoEs and other modes of research project coordination and integration. After 2005, these were in turn linked to enhancing and consolidating excellence in basic research as the foundation of all industrial innovation, through a European Research Council and its advisory Scientific Council at the supranational level of the EU.

An overall claim could thus be made that, as in the USA over the past three decades, U–I–G relationships in Europe have become considerably stronger in order to effect a more capitalist, knowledge-based economy that can succeed in an internationally competitive marketplace. It appears that UIBR has been at times explicitly, and at other times implicitly, fostered through a range of policy-making tools (such as NoEs and the European Research Council) impacting on universities and thus on the economic competitiveness of industry within a consciously constructed ERA.

**Universities on other continents**

It is not feasible here to undertake a comprehensive review of the nature and extent of the spread of the third mission across universities in Asia, Australasia, and so on. I will therefore simply attempt to provide a few insights into some countries outside the USA and the EU, and will suggest that a substantial transformation of university modes of research has occurred across a number of continents. These are all linked to attempts, usually by national governments, to strengthen U–I linkages within their own countries, particularly with regard to UIBR at universities. The NSIs of countries such as Japan, South Korea, China, Canada and Australia are lagging behind those of the USA and the EU, and I hypothesise that, in the search to become competitive in the new global political economy – led by TNCs using new technologies rooted in the basic sciences – a dominant higher education discourse has been emerging in these countries about ways of achieving, in effect, the second academic transformation.

In the case of Japan, for example, as regards the need to enhance basic research and U–I linkages, I suggest that it in many ways ‘follows on’ from the USA and EU
after the late 1990s. Thus it exemplifies the points just made in relation to the EU’s economy about the fundamental role ascribed to frontier research, encompassing university-based UIBR, in strengthening economic competitiveness.

Yamamoto has suggested that the development of Japanese universities, including the seven elite imperial or ‘national’ government-funded universities, played a role in Japanese industrialisation in the 100 years after the 1870s: ‘[The university system] contributed greatly to the development of science and technology in the country. It also played the leading role in developing leaders, administrators, engineers etc. that have sustained the social and economic progress of the nation’ (Yamamoto 1993: 47).

Nevertheless, many of the Japanese twentieth-century industries had originally been ‘created by the USA’ (Hee & Hirasawa 1998: 47). The skill lay in importing the ‘know-how’ of these technologies and then transforming and adapting this within their own high-quality capitalist industry.19 In addition, aspects of the industrialisation strategy were built upon a range of excellent and special forms of Japanese company management and production methods – for example the ‘kanban’ system (introduced in 1953 by Toyota, involving self-monitoring of quality by workers), or the highly sophisticated system of ‘keiretsu’ (major firms linked to a network of dependent supplier firms) (Lapid 1996). None of these innovations was rooted in university-based knowledge – they were all industry-based. Until the early 1970s ‘the Japanese had made little effort to carry out basic research’ (Lapid 1996: 28). When this was eventually developed in the 1970s and 1980s with initiatives such as the Institute for New Generation Computer Technology, it became rooted mainly outside the universities, in places such as a ‘science city’ where industry and industry-based researchers predominated (albeit assisted and advised by some university professors and/or researchers) (Lapid 1996: 28–30).

In the early 1990s, therefore, when government and society in Japan began to wake up to the strength of research-intensive universities in the USA and Europe, their own universities faced enormous problems. Among these were government underfunding of the national universities (in particular, underfunding of research infrastructure and facilities), research grants for professors, salaries for research assistants, and a relatively underdeveloped system of PhD training (Yamamoto 1993; see also Nakayama & Low 1997). Overall, ‘research support to universities compar[ed] poorly with the private support of non-academic research [especially in industry and non-university institutes]’ (Yamamoto 1993: 47).

Since the mid-1990s there have indeed been significant attempts to transform Japan’s universities, attempts that in many ways embody a thrust towards achieving a second academic transformation. For example, the Basic Plan for Science and Technology of 1996 set in motion significant increases in spending on S&T over the next five years, which affected universities in particular (Nakayama & Low 1997: 257). Woolgar (2007) has outlined even more substantial changes effected by the Technology Transfer Law of 1998, which allowed the establishment of licensing offices at universities. This was followed by the establishment in 2003 of Intellectual Property
Headquarters (a Japanese version of the American Bayh-Dole Act)\textsuperscript{20} for universities. Woolgar also notes the big step taken by the National Universities Incorporation Law of 2003, which granted national universities autonomy from government. It was expected that this would lead to greater social engagement by universities – with industry in particular (Woolgar 2007: 1261).

In the mid-1990s it could still be asserted that ‘in postwar Japan, academic science has been overshadowed by private science, as practised in corporate laboratories in particular’ (Nakayama & Low 1997: 256). Nonetheless, the reforms since then seem focused on strengthening the university third mission and the triple helix of U–I–G relations. However, the historical system of major research development outside the universities suggests that this transformation will not be easy to accomplish in the short term.

In South Korea there have also been considerable attempts since the mid-1980s to transform university science. Research at universities at that stage was relatively weak, which hindered the South Korean government in its attempt to shift ‘emphasis from industrial policy to technology policy’ (Hassink 2001: 1380) so that it could begin following the USA and Europe with an enhanced NSI. A series of reforms have therefore been instituted to enhance UIBR at universities. For example, since 1989 well over 60 science research centres focusing on basic science, and ERCs focusing on ‘fundamental technologies linked to industrial development’, have been developed at its major universities, with links to industrial and government-based laboratories (Ahn 1995: 248–249) (see Chapter 3). Hassink (2001) notes a parallel development that began in the mid-1990s of regional research centres linking universities with their regions, particularly to enhance the performance of small and medium-sized enterprises. Clearly, therefore, a central aim has been to achieve an enhanced third mission of universities, incorporating the development of triple helix U–I–G research linkages.

In China, where much (mainly applied) research had been rooted in government institutes and laboratories, there have been thrusts since the mid-1990s to set in motion what is also, in effect, a second academic transformation in its universities, linked to the goal of a more market-shaped NSI (see Motohashi & Yun 2007). The enhancement of high-quality research and doctoral training has been a central aim since 2003, when the government announced the ‘211 Higher Education Project’ – to develop 100 top universities – which ‘opened the way for universities across the country to make strategic bids for acceptance among China’s top 100 institutions and be funded to reach world-class standards in the twenty-first century’ (Hayhoe & Pan 2005: 20). All these efforts are clearly linked to the enhancement of the Chinese economy, through an NSI in which the research-intensive universities are to play a central role.

Some of the strongest thrusts towards a second academic transformation came from Australia and Canada in the 1990s. For example, in Australia a succession of politically diverse governments since the late 1980s all took steps to achieve a much stronger triple helix of U–I–G research relationships to deal with the country’s
perceived ‘competitiveness crisis’ in the global economy. Policies included the establishment of various types of centres of excellence (CoEs) such as IUCRCs after 1990 and, even earlier in the 1980s, ‘special research centres’ based on world-class research (Tegart 1996; see Chapter 3).

Canada, too, has seen one of the most overtly ideologically oriented sets of higher education policies – a transparent second academic transformation – set up to make the country economically competitive, especially with its US neighbour. For example, in 1989 the Canadian federal government set in motion its ‘networks of centres of excellence’ (NCEs), which have aimed to create a network of university professor-researchers and researchers in industry and government institutes, with the university as the core of this triple helix. The NCE programme has been ‘arguably the most dramatic change in the nation’s science policy since the National Research Council21 was established in 1916’ (Fisher et al. 2001: 299).

When Fisher et al. interviewed some Canadian policy-makers about the NCEs in 1999, one of them asserted that they ‘needed pure, long-term applied science that was somewhat guided by the needs of industry’, adding that everyone was ‘grappling with the term “pure, long-term applied science”’(2001: 312). This led Fisher et al. to claim (correctly, it appears) that such officials were referring implicitly to Stokes’s (1997) idea of UIBR. They conclude:

The NCE is an ideological instrument. Its ideological goals have never been hidden: its purpose is to change the research culture…academic researchers must be enlisted in the ‘national system of innovation…[and, quoting the NCE programme annual report of 1996/97] The thrust of the NCE programme is to ensure that knowledge is transferred from the generators [universities] to the users [industry] and applied to benefit the lives of Canadians.’ (Fisher et al. 2001: 322)

The last sentence of this quotation, derived from the NCE 1996/97 report, is perhaps one of the clearest statements from a government body about the need for a triple helix of research relations, and the associated need for a second academic transformation and third university mission of societal and, especially, industrial engagement.

An analysis of Latin America reveals similar thrusts emerging in various countries since the 1990s. For Brazil, see for example Etzkowitz and Brisolla (1999) and Dagnino and Velho (1998); for Latin America in general, see Arocena and Sutz (2001). Furthermore, as the Introduction to Part 2 points out, in South Africa there has also been a growing emphasis since 1994 on the enhancement of triple helix relations under the umbrella concept of our NSI.

In conclusion, however, it is important to note that there is a question that is seldom posed by the international and mainly ‘northern’ writers cited in this chapter – a question that asks: what will happen to the millions across the globe who remain disconnected from the networks of the knowledge society? An exception to this is
Manuel Castells, who refers to Africa’s ‘black hole’ of exclusion, calling it a ‘Fourth World’ – a world that I would view as outside the reach of any triple helix research relations. Castells asserts, moreover, that ‘the notion that this [new global economic] system can proceed forever, while excluding two-thirds of humankind, is simply naïve’ (2001a: 20).

This introduces an initial note of doubt about the current exclusive focus of governments and industry – and similar focus of many academic analysts in general – on the triple helix and on U–I research relations specifically. By implication this involves a neglect of what, in the Introduction to Part 1, I termed the ‘orphan’ relationship of U–CS, and what Castells calls relations with ‘two-thirds’ of global society who are effectively disconnected from networks of ‘industry’. The next section contains further cautionary comments on some of the Etzkowitz hypotheses, and these concerns about the absence of U–CS research relationships are raised at various points in the chapters that follow.

Cautionary remarks about a global second academic transformation

Thus far in this chapter I have assembled a range of indicators from various continents to suggest support for Etzkowitz’s core proposition that a second academic transformation has been spreading internationally across universities. These pointers appear significantly strong in the USA and Western Europe, are emerging quite strongly in areas such as Australia, Canada and parts of Asia, and are even beginning to appear in Latin America and in a sub-Saharan country like South Africa. However, it is important to include some cautionary remarks about ideas of a ‘global onrush’ of this academic transformation since the 1980s.

The discussion that follows stresses two concerns. Firstly, the growth of a third mission – especially around U–I linkages – has been widely debated and sometimes even opposed ideologically, particularly by sections of academia. Secondly, important components of the propositions and hypotheses relating to a second academic transformation, as outlined for instance by Etzkowitz, are disputed. This is true especially of some of the empirical data – relating, for example, to the central role of universities in the knowledge society and, more specifically, to the nature of the new technological transformations.

Questions of ideology

One fairly straightforward ideological response to exhortations to become an ‘entrepreneurial university’ has been what might be termed the ‘Johns Hopkins University approach’ – what Feldman and Desrochers (2004) have observed as the maintenance at this university of its primary historical mission, namely ‘truth for its own sake’ or curiosity-oriented research. In other words, this ideological position does not wish to broaden the third mission, with its current focus on
U–I–G relations, by adding the goal of building strong U–CS relations alongside U–I relations (which is my own position). Instead, the response is to maintain existing elements of, and even retreat into, ‘traditionalism’, by holding the line on PBR.

Historically, Johns Hopkins University gave the lead in the late nineteenth-century USA during the emergence of a small elite group of research-intensive universities focusing on PBR. And still in 2001, as Feldman and Desrochers note, although Johns Hopkins was the single largest university recipient of federal R&D funds in the USA, it was nearly the lowest ranked in terms of industry-sponsored research. Moreover, it lagged behind other research universities when it came to patents, licensing and spin-offs (Feldman & Desrochers 2004: 107, 123). The university did establish a TTO for U–I links in the 1980s, but it has consciously followed a traditional approach, as stated in 2001 by its Vice-Provost for Research: ‘Historically, Hopkins has eschewed turning inventions into commercial ventures. Hopkins was a place where you would come to be an academic person and do research, and that’s that. Most people here today are still here for that reason’ (quoted in Feldman & Desrochers 2004: 107).

The case studies of Western Cape universities in Part 2 of this book show strong elements of such a ‘truth for its own sake’ approach as a conscious reaction in sections of academia. This is particularly true at my own institution (UCT), where this attitude – especially in the arts and natural sciences – has been far more dominant than at its neighbouring HEIs.

In many research-intensive universities the responses have been more complex and nuanced. For example, points made about Chalmers University in Sweden in the Jacob et al. (2003) study cited above illustrate the tensions in research facing many academics across the globe. Chalmers has nineteenth-century engineering science roots, and since the 1970s has increasingly combined basic and applied research and enhanced its commercial links with industry. Jacob et al. found, nevertheless, that in the late 1990s the majority of its researchers were not aware of the existence and/or function of new university structures supporting innovation (for example, the Chalmers Innovation set up in 1998 to facilitate the incubation of firms); they also found that these entrepreneurial initiatives were perceived as diffuse, fragmentary and emerging in an uncoordinated way (2003: 1562).

This is perhaps not just a Swedish phenomenon, but a situation pertaining across higher education internationally. The second academic transformation has been spreading slowly over the past few decades, often taking place through the diverse and uncoordinated initiatives of individual academics, so that it is not yet perceived as a fundamental transformation that will restructure academia as a whole. This is reinforced by the fact that the cutting edges of these changes have so far often focused on relatively narrow academic fields: sections of engineering science (electronics and physics, space science, chemical science) and the new sciences linked to biotechnology, ICT and new materials (including nanotechnology). A lack of perception of fundamental transformation is perhaps less true at leading northern research universities such as MIT, Stanford, Oxford and Cambridge, but
in the south – for example at UCT – changes are often perceived as rooted in a new ‘managerialism’ rather than reflecting basic transformations at the level of U–I–G research relations.22

Jacob et al. made another significant finding in their Chalmers investigation: ‘It was further argued [by interviewees involved in the new innovations] that many members of faculty did not even possess the most rudimentary knowledge necessary for engaging in entrepreneurship’ (2003: 1564). In addition, they found that, even at Chalmers with its long history of applied knowledge, peer review publication ‘is still the main performance indicator for researchers and…commercialization or commodification of research results is invariably a time consuming process [taking time away from research itself]’ (Jacob et al. 2003: 1566). Thus, in addition to lacking understanding of a fundamental academic transformation that was taking place, some academics either lacked the knowledge of how to connect with it, or preferred to focus on traditional PBR.

Many of these factors, which are slowing or impeding the third mission of university contribution to socio-economic development through research, are reinforced by various forms of ideological opposition to this transformation. Jacob et al. linked this to questions and concerns pertaining to the public good, which also need to be raised in countries such as South Africa. They note that in Sweden, research has been seen as a public good, undertaken historically by universities funded by the taxpayer. What are the implications of using large public investments (such as laboratories, libraries, academics’ time) in knowledge creation leading to private wealth (profits for shareholders of industry)? It seems that those like Etzkowitz who argue enthusiastically for the triple helix model, assume – usually implicitly – that U–I–G research partnerships will lead to wealth trickling down into civil society for the benefit of all. But will it? Is there any evidence to show that the trickle-down effect is anything other than a convenient rationalisation made by those at the top of the economic heap?

I would hope that the issues opened up by the Swedish debate will become much more strongly asserted in the international literature on the entrepreneurial university:

> The problem of accommodating the value of commercialisation and commodification in a context of the Swedish University system where the social function of the university had been previously seen as part of a general social welfare ethos is one of the main issues to be confronted when building an entrepreneurial university. (Jacob et al. 2003: 1566)23

An allied question that needs to be addressed concerns the historical roots of the idea – even the ideology – of NSIs. In fact, research policy literature around the idea of NSIs has risen to prominence, especially in the EU, and has evolved historically around specific groups of academics. Since the late 1980s these academics have been directly linked to the role played by the Organisation for Economic Cooperation and Development (OECD) and other European government ‘think tanks’. As mentioned above, Sharif (2006) made a study of a cluster of these academics, among them
Freeman, Pavitt, Nelson, Lundvall and Dosi. Dosi has referred to the ‘interpretative framework’ of their group as the ‘Stanford-Yale-Sussex (SYS) synthesis’ (Dosi et al. 2006: 1451). Sharif’s study points clearly to the forceful role played by these academics in the evolving policies of the OECD, which have fed both directly and indirectly into the EU FPs since the mid-1980s. For example, his investigation showed how, with reference to what he calls the ‘National Innovation System concept’, there was a ‘genesis and development’ of a common set of ideas and ‘understandings’ among these academics – in opposition to ‘orthodox economic theory for not considering the fundamental role and special character of technical change’ (Sharif 2006: 750).

In contrast to orthodox, neoclassical economics, with its post-1970s neoliberalism and its focus on market forces, the SYS group thus stressed technology and social institutional factors, including national research organisations (Sharif 2006: 753). This led directly to their ideas of societal ‘innovation systems’ and the ‘knowledge-based economy’, which – as I argued earlier in this chapter – have now become so central to FP6 and FP7. Sharif (2006: 754) has described the emergence and consolidation of this set of academically rooted ideas as the ‘formation of an NIS [National Innovation System] epistemic community’ – which developed close links, from the late 1980s onwards, with OECD committees and governmental policy discussion groups. Important components of the current science policy frameworks of many countries are based strongly on such thinking. This includes South Africa, as will be outlined in the Introduction to Part 2.

Sharif’s findings resonate with the work of Ruivo (1994), in a study of how a common set of science policies can become everyone’s understanding. As Ruivo puts it, in relation to this ‘internationalisation’ of science policies:

> The dissemination of ideas occurs through what we call ‘international relations in science policy’, that is, the contacts at international level, through intergovernmental bodies, on views about special policies and their instruments. International organizations and other multilateral bodies [she mentions the UN, the OECD and the European Community] have been playing an important role, although national realities and traditions such as those of public administration also influence and shape science policies. (1994: 161)

The points raised above regarding the ideological diffusion of the NSI concept and associated ideas – including its widespread presence in international science policies – are not meant to deny the value of the concepts introduced by the SYS group. They (re)focus economics onto questions of technology, innovation and research, and sometimes even indirectly onto issues of UIBR and the second academic transformation. Nonetheless, it is essential that an ‘interpretative framework’ revolving around the idea of NSIs be viewed, like all socially constructed idea systems, as ideological: it has certain foci and not others, it contains some truths, but at the same time neglects or fails adequately to address certain questions. Among these ‘absent issues’ are U–CS relations and a critical examination of ‘the public good’,

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especially in developing countries. Like all ideologies, this ‘NSI interpretation of the world’ must be treated as embodying a politics and a value system, particularly in relation to issues of ‘capitalist economic competitiveness’ and ‘innovation anxiety’, which need to be questioned and confronted – especially since they seem to underpin so much of national (and transnational) science policy on U–I–G relations.

The discussion now turns to another aspect of the interpretation of Etzkowitz’s central idea of a second academic transformation that requires attention: whether more empirical research is needed on a variety of questions associated with his set of hypotheses outlined at the beginning of this chapter.

Questions of empirical evidence

One empirical question that must be answered is whether a technological revolution has in fact been taking place. Hopkins et al. (2007) have posed this in dramatic form in the title of their important article ‘The myth of the biotech revolution: An assessment of technological, clinical and organizational change.’

These authors do not deny that there has been a significant global expansion of biotech firms arising from basic science discoveries in microbiology, linked especially to genetics:

Since the early 1980s a very large and well-financed global biotechnology sector has developed, growing from just a few pioneers in 1980 to nearly 300 biotech firms in the US alone by 1988...Investor enthusiasm has led this population to grow to an estimated 4 000–5 000 businesses globally [around 2004]. (Hopkins et al. 2007: 580)

Hopkins et al. nonetheless believe that this ‘over-enthusiasm’ has been accompanied by excessive hype about a biotech revolution, which is not supported by empirical evidence. The data they provide focus on two main critiques: firstly that the changes in productivity of the new biotech industrial sector have been overestimated in both extent and growth rate, and secondly that the quality of therapeutics derived from this bioscience, especially within clinical practice, has not yet been enhanced in any ‘revolutionary’ way.

Concerning the first argument, Hopkins et al. (2007: 567) argue that the translation of fundamental discoveries in bioscience into new and effective technology is more difficult than many S&T policy-makers suggested previously. In particular, new drug development (the period of R&D, from a drug prototype entering pre-clinical testing until actually approved by the regulatory authorities) has been much slower and more costly in biotechnology than had been expected. Productivity measured in terms of drug approvals has therefore not expanded in any revolutionary way (Hopkins et al. 2007: 583).

In terms of their second argument, Hopkins et al. note that many of the new ‘biotech’ drugs have seen success in the (well-publicised) treatment of relatively rare conditions such as anaemia and multiple sclerosis, while ‘biotechnology has had
little impact on primary care medicine. The route from academic ‘bench to clinic’ has thus not been revolutionary at all (Hopkins et al. 2007: 577–580). Interestingly, however, Hopkins et al. acknowledge that there is an ongoing transformation in industrial structure and organisation. Their data suggest that, increasingly, small biotech firms linked to the work of university researchers are forming alliances with large pharmaceutical transnationals. The smaller firms secure the initial R&D, and the large companies use their platform technologies to industrialise the drug development through economies of scale and scope (Hopkins et al. 2007: 581). Thus new forms of knowledge coordination-cum-industrial organisation have been emerging (through small–large firm insource–outsource networks) but these often need enhancement to become economically effective.

In essence, therefore, Hopkins et al. (2007) do not deny that major transformations in biotechnology have been under way, but they believe that the infrastructure of technology and industrial organisation, and the clinical practice to exploit the bioscience discoveries, still remain immature. In the light of this, one might perhaps rephrase Etzkowitz’s hypothesis regarding the speed of the second academic transformation in the following way: the first academic transformation, which began in Germany in the early 1800s, spread slowly across universities of Western Europe and the USA over a period of nearly a century; the second academic transformation of the late 1900s – itself linked closely to current technological transformations – will probably take at least half a century to consolidate itself internationally!

There is another empirical question found in some of the literature regarding the role that fundamental knowledge/basic science does actually play, and might in future play, in technological development. Simply stated, the question is this: is basic science now a vital factor for economic development? Allied to this is the extremely difficult subsidiary problem of how one can assess the impact of basic science discoveries on the knowledge-based economy, especially over the medium to long term. This question has already been posed explicitly in the debates which Hopkins et al. (2007) have entered into regarding the impact of bioscience on a biotech economy and its associated clinical practices.

Godin (2004) links such questions to a critique of the OECD as a ‘think tank’. During the 1990s the OECD introduced a series of buzzwords and catchphrases such as ‘high technology’, ‘national system of innovation’ and ‘new economy’. As noted earlier, both Sharif and Ruivo have pointed out that such concepts have shaped entire S&T policies in Western countries. In a similar vein, Godin claims that there is a lack of hard evidence for a strong causal relationship between basic science discoveries and economic development:

Despite 40 years of development, the field [the mathematics behind economists’ models] is still plagued by important methodological limitations that prevent anyone ‘proving without doubt’ the impact of science and technology on productivity. As the OECD constantly reminded its readers: everyone is convinced of the contribution of science and technology to
the economy (imagine a world without technologies); but statistically, the demonstration [of the link between scientific knowledge and economic growth] remains limited. (2004: 681)

Such points are important, and will be seriously considered in the chapters that follow, although I will argue that despite difficulties in measurement, there is nonetheless substantial evidence of major impacts of the ‘new technological regime’ on the economy. For example, in the next chapter the argument for a revolutionary impact of UIBR on industrial development, at least in the USA, is broadly supported using a qualitative approach (rather than with economic models): it examines the historical emergence of physics linked to engineering, at for example MIT and Stanford before the 1970s, to highlight the effect of the science of electronics on a new knowledge-based economy. This is followed by a theoretical argument regarding the emergence of new ‘forces of production’ (new technologies linked to UIBR) and their impact, since the 1980s, on the third capitalist industrial revolution. And in the Western Cape case studies in Part 2, I explore the OECD idea of the importance of science, particularly UIBR, in achieving a transformatory impact in certain industrial spheres (e.g. agricultural biotechnology and space satellite production) for economic growth – although I have a less single-minded enthusiasm for U–I–G relations than the OECD. Nevertheless, I argue throughout this book that Godin’s question forces one to be much more nuanced and circumspect with regard to the global impact of the post-1970 ‘new technological regime’, especially with regard to the complex economies of developing countries such as South Africa.24

Godin’s doubts lead to a further question about one of Etzkowitz’s hypotheses: even if a second academic transformation is conceded as an emerging reality (with university science now closely linked to industrial development), has the university become a leading institution for the enhancement of the new knowledge-based economy?

There is considerable dispute in the literature about the extent to which universities are central to the new economy, and in particular to an NSI. Gibbons et al. (1994), for example, have argued that university research groups and networks are increasingly merely a few among many groupings that are cooperating and competing in the new production of knowledge in contemporary societies. In a different study, based on Canadian bibliometric data of scientific publications, Godin and Gingras (2000) found that publications by researchers working in health, industry and government organisations outside universities increased significantly over the period 1980–95. This supports Gibbons et al.’s thesis of the diversification of knowledge production, although during the same period Godin and Gingras found a substantial increase of co-authoring by researchers from each of these sectors with university academics, suggesting that universities do remain at the centre. Thus they assert that:

…despite a real diversification of the loci of production, universities still are at the heart of the system and…all other actors [in hospitals, industry and government laboratories] rely heavily on their expertise…[Moreover]
though our data are limited to Canada, everything suggests that the trends should be similar in other countries as well. (Godin & Gingras 2000: 274)

This issue of the relevance of the role of the university as an institution in the new knowledge-based economy will be explored through the Western Cape case studies. From another angle, the question has also given rise to a very wide range of studies over the past two decades involving empirical investigations of what is ‘going on’ within universities in relation to transformations arising, in particular, from U–I–G research relationships. New findings, all of which might be considered as falling within the new fields of higher education studies and S&T studies, are emerging in many different sub-areas of investigation (academic staff, PhD training, links with industry or government, financing research in an NSI, and so on), but these cannot be explored here.

Some insights into such findings can nevertheless be attained by briefly mentioning a few very interesting issues emerging from studies led by Bozeman, a leading researcher in the field. He and his colleagues have produced a series of fascinating studies over the past few years, particularly into ‘modes’ of research organisation (e.g. research centres and networks) – a central issue framing the way I organise the 11 case studies in Part 2. One investigation, which examined large-scale, multidisciplinary research collaborations and networks between research groupings across institutions, found that in order to be successful, such inter-institutional efforts need a relatively high level of development of at least one of two social components. The first of these is related to the epistemic norms of the disciplines: during networking, collaborating disciplines need clear and agreed norms and practices for research procedures and research goals. The second is the organisational structure of the collaboration: financed, structured and managed relationships are necessary (Corley et al. 2006: 975). They conclude that much more attention needs to be given to the internal design of research collaboration networks, both ‘epistemically’ and ‘organisationally’ (Corley et al. 2006: 992). This is similar to some of the Western Cape findings described in Part 2.

Another study associated with the Bozeman projects involved a wide-ranging questionnaire survey of faculty members participating in multipurpose, multi-discipline university research centres (MMURCs) in the USA. The survey found that untenured junior staff of these centres were caught between conflicting values: peer-reviewed academic publications required for tenure versus more use-oriented forms of scholarly publication (such as project reports) and contributions (such as patents) for research sponsors (Boardman & Ponomariov 2007). They conclude that:

…the ‘second academic revolution’ (Etzkowitz 2001; Etzkowitz & Leydesdorff 2000) is incomplete in that it has not yet won the hearts and minds of all (e.g. junior-level) university scientists…[and] the current university reward system in the U.S. may indeed be deterring junior-level scientists from performing the applied and commercially relevant
A third study (Bozeman & Gaughan 2007) focused on the impact of research grants and contracts on the nature and extent of faculty research and technology activities in collaboration with industry. It found a positive correlation between grants and contracts from industry and an academic researcher's propensity to work with industry. While comprising only a small fraction of the much wider range of studies needed for more conclusive evidence, the investigations of Bozeman et al. and others point to the fact that substantial changes in research practices seem to be under way. These are surely associated with Etzkowitz's 'second academic revolution' – although the transformation is more complex and conflictual, and more diffuse and slower than suggested by his hypotheses. The analysis of the Western Cape case studies seeks to convince that such a transformation is indeed emerging at South African universities, while also highlighting the key factors that are inhibiting (and enhancing) this revolution.

In conclusion, there is an important question, posed in a number of works by leading writers on university research, such as Mowery, Rosenberg, Nelson and others, which needs consideration. This is particularly relevant in the next two chapters, where I argue that there was a crucial shift in forms of university research in the last quarter of the twentieth century associated with a second academic transformation, itself linked to the new and vital role of university UIBR in symbiosis with a third capitalist industrial revolution. Some of the articles of Mowery and his colleagues (for instance Mowery et al. 2004) suggest, however, at least indirectly, that there has been no sharp break or 'second academic revolution/ transformation' at universities in the USA. They claim that throughout the twentieth century substantial applied research took place within the American university system, and that this increased linearly after the Second World War. This in turn raises a question about my detailed argument (in Chapter 2) that in fact there was a turning point in the way in which basic science at American universities began to link up strongly, through UIBR, with technological developments, and that this initial moment of shift occurred during the Second World War. This provided embryonic developments, I argue, for the eventual major 'take-off' of a new (third) industrial revolution after the 1970s, supported by much more theoretically driven, university-based science – a real break or non-linear development from the 1980s onwards, linked especially to UIBR.

In contrast, the approach taken by Mowery et al. (2004) asserts that there has been a long history of applied research at American universities, beginning well before 1900 and linked especially to more 'vocational' university fields such as agriculture, mining and commerce. They point out that the 'new applied' disciplines of engineering (such as chemical, mechanical and electrical) had become consolidated at American universities well before the Second World War (Mowery et al. 2004: 55–54).
Chemical engineering is a classical case cited (Mowery et al. 2004: 16; see also Rosenberg 2000). They suggest that it is not really applied chemistry but rather a merger of chemistry and mechanical engineering. Thus, they say, ‘by the start of World War II, the applied sciences and engineering disciplines were well established within U.S. higher education’ (Mowery et al. 2004: 20).

The argument of Mowery et al. (2004: 23–27) – that there was a gradual, linear development of university science linked to industry – is extended by them also to the 50 years after the Second World War. For example, led by a massive expansion of federal government funds for research at American universities after 1945, the federal share of total academic research funding at universities was still 60 per cent by 1995. While they point out that a considerable amount of this federal funding was directed at what they term ‘applied research’ (linked to the NIH, the Department of Defense, and so on) (Mowery et al. 2004: 25, Table 2.2), they nevertheless acknowledge that this was often interlinked with basic research work. In summary, they suggest a significant – but linear – expansion of university applied research after the Second World War, with most federally funded research at universities by the end of the 1990s linked in complex ways to use-oriented research work (including UIBR).

This outline by Mowery et al. of a long twentieth-century history of use-oriented research embedded in the American university system is of great value and full of rich data, but it left me with two worries. Firstly, if there had been such an unchanging, albeit expanding, form of university ‘applied research’ throughout the twentieth century, how is one to understand a point made by Schweber in his analysis of physics and engineering at MIT and Cornell before and after the Second World War? He notes that, after their experience of basic science for the war effort, Cornell’s new department of engineering physics was set up in 1948 ‘to provide a type of training that would effectively bridge the gap between that of the basic sciences and engineering’ (Schweber 1992: 175; my emphasis).

Schweber also notes that at Harvard – arguably the apex of universities in the USA – the Department of Engineering Sciences was renamed in 1946 as the Department of Engineering Sciences and Applied Physics. And in Britain even earlier – in 1944 – a special committee of the Ministry of Education, convened to look into post-war engineering education, ‘concluded that in the postwar period a new class of university-trained engineers, well-versed in fundamental science, would be needed by British industry’ (Schweber 1992: 174).

These quotations from Schweber – suggesting the beginnings of a break in engineering science training around 1945 (with early incorporation of more basic science) – connect to my second concern, one based on personal experience. As mentioned in the Introduction to Part 1, in the late 1960s I completed an electrical engineering degree at UCT in what was known as ‘ElecEng B’. Our cohort was viewed as significantly different to – even as a different subculture from – the ‘ElecEng A’ group with whom we sometimes shared a class. As I also noted in the Introduction, we did not fully realise that this was the cutting edge of a new technological regime.
of the third industrial revolution – of ICT and the internet and satellite TV and suchlike. Nonetheless, it was clear to us – as is clear, too, in the quotations just cited from Schweber – that we ElecEng Bs were following a much broader engineering-cum-physics curriculum, in very much the direction set after 1945 at universities such as Cornell and Harvard, as well as in the UK. We were thus much more closely linked to UIBR than were the ElecEng As, who were following in essence a PAR-focused engineering career in power supply and electrical machines. There were in fact two different cultures embodied in the two electrical engineering streams (as was the case for the two chemical engineering streams referred to in endnote 29).

Perhaps, therefore, we need to consider the hypothesis that, sometime around the Second World War or soon thereafter, new forms of applied science were emerging in embryonic form – much more strongly combining basic science with engineering and leading eventually to a sharp break around the 1970s. This ‘break’ was associated with a global capitalist economic slowdown (even crisis) of production in the late 1960s–early 1970s, resulting in capitalist firms (especially TNCs) turning much more to universities to seek out cutting-edge scientific innovations – in order to provide themselves with a competitive advantage within the international market (i.e. ushering in a new capitalist industrial revolution).

Some of these questions are considered in the historical investigation of the period from the 1930s to the 1970s presented in the next chapter, in particular with reference to engineering–basic science linkages at MIT and Stanford. Following this, Chapter 3 returns to a theoretical discussion of the issue of the 1970s break with an older technological regime linked to the last phase (the 1960s) of what I term the second capitalist industrial revolution. This is contrasted with a new regime, linked to the more scientific theory-led third industrial revolution after the 1970s. If this argument is correct, then Mowery et al. (2004) have underestimated the revolutionary break in both industrial production and its associated university-based UIBR in the last quarter of the twentieth century – captured by my hypothesis of a post-1970s new capitalist industrial revolution symbiotically linked to a second academic transformation.

Notes
1 As noted in the Introduction to Part 1, the term ‘academic transformation’ is preferred so as to avoid confusion with ‘industrial revolution.’
2 That is, the ‘ideal of pure enquiry,’ without concern for use.
3 As noted, all quotations for these hypotheses are from Etzkowitz (2002: 150).
4 Leydesdorff and Etzkowitz jointly developed the idea of the triple helix from the mid-1990s (see Etzkowitz & Leydesdorff 1997), linked to Etzkowitz’s idea of the second academic revolution.
5 The exact disciplinary area, for reasons of confidentiality, is not described by Colyvas.
6 The first disclosure of 1970 became one of the top-earning inventions in Stanford’s history (Colyvas 2007: 464).
Studies for the 1990s show a similar significant increase in France in the commercialisation of university biotechnology knowledge (Mangematin 2004) and across Western Europe in general (Corolleur et al. 2004). This is discussed further in the section on Europe which follows.

Corley et al. (2006: 975) clearly capture this development ‘from below’ with reference to other studies: ‘Hagedoorn et al. (2000)…emphasize that organizations collaborate on research projects to gain access to resources and capabilities that enable them to develop and sustain competitive advantages’. See also Jong (2008) for a specific case study of academic initiatives and the rise of biotechnology at Stanford and Berkeley during the 1980s and 1990s.

Geiger’s (1986) first book focused on American research universities for the period up to 1940, while the second book (1993) considered developments up to the end of the 1980s. Geiger’s use of the term ‘generic research’ (see further below) is close to what, following Stokes, I have referred to as UIBR (see Geiger 2004: 203).

The three universities were Oxford University, the ex-polytechnic Oxford Brookes University, and Cranfield University (the Defence Science, Technology and Management section of Cranfield University in Buckinghamshire), while the Rutherford Appleton Laboratory, the UK Atomic Energy Authority and some Medical Research Council units were included among the seven government-funded and privatised public laboratories.

Their definition of spin-off companies involved technology-based companies founded by a member, or former member, of one of the three universities or seven laboratories, using IP developed in the institution by the founder(s), whether or not the institution owned some of the IP of the new company itself.

These spin-offs included companies focused on measuring instruments, optoelectronics, the motor industry, nanotechnology, and a cluster of other focus areas (15%), including consultancy, aerospace, nuclear, robotics, and glass engineering. No firms seem to have been focused on social science research fields, an issue which will be discussed in Part 2 with reference to the Western Cape case studies, where two of the 10 application-oriented case studies were in the social sciences.

South Africa’s R&D expenditure is currently considerably less than this, at just under 1 per cent of its GDP (see the Introduction to Part 2).


I argue in a later chapter that by the time of FP6/FP7 (after 2000), the threat to the EU by the innovative, knowledge-based economy of the USA was viewed as more important than that of Japan.

In countries like France (CNRS), Germany (Max Planck Institutes) and Hungary (Academy of Sciences), significant academic research is located formally outside the universities. Drawing in such non-university institutions alongside U–I has thus been an important thrust of some of these NoEs (see also Chapter 3).

This cluster of academics was investigated (and interviewed) by Sharif (2006). Their influential ideas on NSIs during the 1980s and 1990s and their impact on EU FPs are considered later in this chapter. The group included Freeman and Pavitt from the UK, Lundvall and Jacobsson from Scandinavia, Nelson and Rosenberg from the USA, and Dosi from Italy.
See also Matsumoto (1996) for discussion of how Japan transferred and skilfully adapted the technology of the marine steam turbine from Britain in the early twentieth century.

Also known as the University and Small Business Patent Procedures Act, this 1980 legislation dealt with IP arising from federal government-funded research. Among other things, it gave US universities, small businesses and non-profit organisations control of their IP (including inventions) that resulted from such funding.

Similar to the South African Council for Scientific and Industrial Research.


See also Slaughter and Leslie (1997) on ‘academic capitalism’ in the USA.

Interestingly, as will be seen in the next chapter, the academics at MIT and Stanford, as distinguished engineering scientists (including during the Second World War), never doubted their leading role in making possible a positive answer to the question of whether (their) science was fundamental to economic development.

While Mowery et al. make this point in other articles (e.g. Mowery & Sampat 2005; Rosenberg 2000; Rosenberg & Nelson 1994), the 2004 article cited here is a useful, condensed outline of the essential questions.

‘Chemical engineering is not applied chemistry and cannot be adequately characterized as the industrial application of scientific knowledge generated in the laboratory. Rather, it involves a merger of chemistry and mechanical engineering, that is, the application of mechanical engineering to the large-scale manufacture of chemical products’ (Mowery et al. 2004: 16).

With reference to such basic-cum-applied research, Mowery et al. (2004: 26) support their arguments by citing Stokes’s idea of ‘Pasteur’s Quadrant’ of UIBR. This concept is discussed in detail in Chapter 2.

Rosenberg (2000) describes chemical engineering as a combination of chemistry and mechanical engineering (see also previous footnote with reference to Mowery et al. 2004). The ElecEng As were in fact doing what could be seen as a combination of electrical (non-electronic) and mechanical engineering.

By the late 1960s there was already also a division at UCT between ChemEng As who were (much as described by Rosenberg) dealing with petrochemical industrial plants, etc. and ChemEng Bs, whose curriculum was more a combination of ‘physics-chemistry + engineering’ – thus similar in many ways to the ElecEng Bs. This difference in chemical engineering curricula seems not to have been assessed by Rosenberg. By 2000, some UCT ‘chemistry science-engineers’ were moreover incorporating areas such as biotechnology into their curriculum (personal communication from academics in chemical engineering, UCT).
2 Use-inspired basic research and the third mission: Some cases of early developments

The previous chapter began by considering a series of hypotheses by Henry Etzkowitz linked to his concept of the contemporary ‘second academic revolution’ (or ‘transformation’, as I call it in this study). This chapter will take a more historical approach, building upon some of the ideas developed by Etzkowitz in his book *MIT and the Rise of Entrepreneurial Science* (2002) about the early development of the ‘third mission’ at MIT before the Second World War and at Stanford after the war. It will also consider his argument about how numerous American universities were similarly transformed to link their research to the ‘war effort’ during the 1940–45 period.

A central purpose of this chapter is to highlight – with reference to cases such as MIT and Stanford in the area of engineering-physics in particular – that the global spread of a second academic transformation in the last quarter of the twentieth century began long before the 1970s. Such deep transformations emerged, I suggest, in embryonic forms some time earlier – from the 1930s onwards in the case of MIT, and post-1945 for Stanford. Moreover, I hope to show that such ‘big’ global academic changes involve a long period of historical gestation, with a considerable series of trial-and-error practices at institutions such as MIT and Stanford.¹

Having examined the origins of this process of transformation, I will then argue in Chapter 3 that it was the international economic ‘crisis’ or slowdown of the early 1970s that led to TNCs turning to research-intensive universities, initially in the USA and later more globally, and that this in turn led to the rapid spread of the second academic transformation across continents from the 1980s onwards. This chapter also seeks to link the work of Stokes (1997) to the historical narratives of MIT and Stanford and Second World War university research transformations. By joining Stokes’s concept of UIBR to the story of MIT in the 1930s, I seek to show that Etzkowitz underestimates the crucial role that basic science (especially physics) played in the early stages of the second academic transformation. I argue that only by introducing the idea of use-inspired *basic research* into the story can one fully appreciate the strength of the transformation that took place at these universities.

At an empirical level, the unfolding story seeks to show how, in their ‘making’ of a second academic transformation before the 1980s, the MIT and Stanford academics acted as both basic science researchers and applied researchers: they slowly constructed new practices and formal academic rules to facilitate basic research with a use-orientation linked to the marketisation of new technologies. Some new practices, as will be seen, were also based on the development of larger, centre-type...
modes of research organisation to facilitate their work. This sets the scene for some of the analysis presented in Part 2, where it will be observed that many of the battles fought by the 10 Western Cape use-oriented research groupings during the period 2000–07 were not unlike those experienced by researchers at MIT and Stanford during the decades up to the 1970s. At a theoretical level, this chapter seeks to provide a ‘historical sociological’ reading of Etzkowitz’s (2002) work alongside that of Stokes (1997), in the hope of clarifying the conceptual links between UIBR, the second academic transformation, and U–I–G research relations.

The chapter ends by moving beyond this period into the early 1970s to explore briefly the case of how UIBR began to penetrate into the biosciences at Stanford as a leader of genetics research, thereby laying the foundation for new practices associated with IP for the ‘marketisation’ of biotechnology by this university in the 1970s, before many other institutions followed in the 1980s.

**Pasteur’s Quadrant and UIBR**

Figure 2.1 captures the essential elements of Stokes’s typology of research, which provides the foundation for discussions in this and later chapters. This figure shows four cells or quadrants. For three of these Stokes takes a famous historical figure as an iconic example of a researcher working in that mode. The top left cell refers to scientists who do PBR, which he defines as ‘the quest for understanding without thought of practical use’ (Stokes 1997: 73); in later chapters I will also refer to this as ‘curiosity-oriented’ research. His iconic example of this is Niels Bohr and his work on the structure of the atom. The bottom right cell covers scientists engaged in PAR, which Stokes defines as ‘extremely sophisticated, although narrowly targeted on immediate applied goals’ (1997: 74). Here his example is Thomas Edison, specifically Edison’s work on electric lighting. Stokes suggests that the bottom left cell (oriented neither to use nor to seeking fundamental understanding) is not ‘empty’. It includes research that ‘systematically explores particular phenomena without having in view either general explanatory objectives or any applied use to which the results will be put…’ (Stokes 1997: 74, author’s emphasis).

**Figure 2.1 Stokes’s quadrant model of scientific research**

<table>
<thead>
<tr>
<th>Is the research inspired by considerations of use?</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is the research inspired by a quest for fundamental understanding?</td>
<td>Pure basic research (Exemplar: Niels Bohr)</td>
<td>Use-inspired basic research (Exemplar: Louis Pasteur)</td>
</tr>
</tbody>
</table>

Source: Adapted from Stokes (1997: 73, Fig. 3–5)
But what interests Stokes most is the top right cell, ‘Pasteur’s Quadrant’. This represents UIBR, and Stokes says that it ‘includes basic research that seeks to extend the frontiers of understanding but is also inspired by considerations of use’ (1997: 74). He provides the example of Louis Pasteur, who was frequently inspired in his basic research by problems faced in contexts of application – for instance, requests for help from Lille industrialists having difficulty in making alcohol from beets. Pasteur was simultaneously dealing with theoretical problems in order to advance fundamental knowledge in his field – for example in crystallography. Stokes suggests that at different moments in his life Pasteur had a stronger focus either on the fundamental side or on the applied side, but he asserts nonetheless that the unity of Pasteur’s work must be conceptualised as UIBR: ‘[Pasteur] probed ever more deeply into the processes of microbiology by accepting applied problems from a Lille industrialist, from the minister of agriculture, even from the Emperor Napoleon III’ (Stokes 1997: 13). Stokes reinforces this point in an endnote: ‘This mix of discovery and practical triumph characterized the whole subsequent course of Pasteur’s career, as he worked out the details of his germ theory of fermentation and disease’ (1997: 154).

Stokes is asserting that we need to conceptualise UIBR as not simply an adding together of PBR and PAR, but rather as something new, a synthesis giving rise to a novel form of research that is more than the sum of its parts. One of his most pertinent examples of UIBR is drawn from modern physics research that fused the goals of fundamental understanding and use: the development of atomic weapons during the Second World War. The US government assembled a group of leading nuclear and other scientists in the Manhattan Project to do research that led to the dropping of the first atomic bomb, on Hiroshima. Stokes makes it clear that many of the scientists involved in this project felt morally guilty about having developed atomic weapons. They also felt uneasy about the highly organised and government-directed group structure of their research, so different from their pre-war status as individual scholars involved in autonomous fundamental research. Interestingly, in some of the post-war memoirs and other writings of these scientists, ‘the result was a strong tendency…to remember the Manhattan Project as a gigantic exercise in applied research and development, and not as a remarkable effort in basic research as well’ (Stokes 1997: 15–16).

In other words, some of these scientists sought to deny the reality of UIBR because it tainted their identity as basic scientists driven only by curiosity, in search of ‘the truth’. As a result, they reconceptualised this work as PAR, temporarily undertaken during the moment of war.

Stokes stresses that throughout the twentieth century the conceptual framework of ‘basic’ versus ‘applied’ research was deeply embedded in the minds of most American university academics. For various reasons, there seemed to be strong opposition to the very idea of Pasteur’s Quadrant. When Stokes was serving on a council advising the director of the National Science Foundation (NSF) in 1979, he so startled the council when he described the concept of UIBR that he had to draw a diagram – like Figure 2.1 – in an attempt to convey his point. Yet for years afterwards he failed to
break through their mindset, resulting in his decision to write a book on these issues (Stokes 1997: ix–x).4

Why was there this remarkable history of denial of Pasteur’s Quadrant by European and American science during the past century? With reference to this, Stokes ventures some historical analysis of Western science, and its deep ideological need for a conceptual and even moral ‘separation of pure from applied’ science (1997: 34).5

What is particularly relevant here with regard to the mid-twentieth century is Stokes’s argument that this dichotomy of ‘pure versus applied’ was reinforced in the USA after the Second World War, due to unusual circumstances described later in this chapter in more detail. He suggests that, despite the extensive role of American scientists in UIBR during this war, in 1945 the ideology of the ‘ideal of pure enquiry’ was consolidated by Vannevar Bush’s proposals in his report Science, the Endless Frontier (1945). At the end of the war, President Roosevelt had invited Bush, who was president of the Carnegie Institution and a former vice-president of MIT, to develop proposals for a peacetime national science system. Bush and other academics were looking for a way to continue the level of federal support of basic science, which had been increased during the war years. At the same time, however, they wanted to push back government control of research, which had also become stronger because of the war (Stokes 1997; see also Crow & Tucker 2001; Etzkowitz 2002). The Bush proposals of 1945 thus stressed two elements: the autonomy of basic science within universities, through the idea of funding of ‘basic research [which] is performed without thought of practical ends’ (Stokes 1997: 3),6 and the role of science as driver of economic development, through the idea that ‘basic research is the pacemaker of technological progress’ (1997: 3).7 This set the scene for the dominance of a post-Second World War view of science in which there was virtually no ideological space for an idea of ‘use-inspired basic science’ (though, as will be seen later, the reality at universities was much more complex).

I have given this exposition of Stokes’s ideas in considerable detail because of the importance of the concept of UIBR for the chapters that follow. His work has undoubtedly contributed to a historical appreciation of the depth of the ideology of curiosity-oriented or ‘pure science’ in many universities – an ideology that is an important factor in the Western Cape cases in Part 2.

It is thus relevant at this point to summarise the terminology which I will apply in this work throughout the chapters that follow, clearly shaped by Stokes’s concepts (see Figure 2.2). Under the broad heading of ‘the investigation work spectrum’, I shall distinguish between research – the production of new knowledge – and non-research or ‘routine consultancy’ (no new knowledge production).8 And within the research or ‘new knowledge’ region itself, I shall refer often to PBR as ‘curiosity-oriented research,’ while the term ‘use-oriented research’ will apply to both UIBR and PAR. Thus ‘routine consultancy’ will be viewed as important (use-oriented) investigation work, but not falling within the category of use-oriented research (UIBR and/or PAR).
Finally, it is useful to conclude this part of the discussion with a comment by Crow and Tucker which captures indirectly what has already been suggested about the American (and European) research-intensive university tendency to avoid or deny the concept of UIBR, for the period after 1945 until at least the 1980s (when the third mission had begun to take root more widely):

While Bush [after 1945] was successful in designing a system that has led to an unprecedented federal financial commitment for university-based basic research, structured to provide significant grants of autonomy, this commitment was at the expense of a true accounting of the innovation process. Bush chose to de-emphasise the university as a performer of anything other than basic research, as well as the spectrum of research to which universities contributed, despite his knowledge of the subject. (Crow & Tucker 2001: 3)

What Crow and Tucker are alluding to in the last part of this quotation is the fact that, although Bush did in 1945 thrust forward ideological proposals for a ‘divorce’ between basic science and applied science, he had in fact played a very different role when he was a university professor at MIT. After completing his PhD there in electrical engineering, he was heavily involved during the 1920s and 1930s in consulting, patenting and firm formation (one of the companies became part of Texas Instruments) (Etzkowitz 2002: 2–3). Yet, at the same time, first as a lecturer and researcher and then as dean of the Engineering School at MIT, he became recognised as a distinguished academic scholar, combining basic and applied research in a complex mixture. In a 1935 tribute, for example, MIT president Karl T Compton described Bush as a ‘dynamic genius’ who ‘introduced operational calculus into modern electrical engineering…and [was] the originator of a series of highly useful machines for performing difficult engineering computations’ (quoted in Etzkowitz 2002: 64). Interestingly, too, despite not using this concept, President Compton in effect made UIBR central to many of MIT’s practices from the 1930s onwards.

The discussion now turns to what I view as the significance of the (indirect) development of UIBR in fields of research at MIT before 1945.
Embedding a third university mission linked to UIBR at MIT before the Second World War

MIT’s beginnings: From 1862 to the 1920s

Although MIT was founded in 1862 (and was known as Boston Tech until 1916), it took its first president, William Rogers, and his academic colleagues several decades to begin to establish a university with a unique and solid mission (Etzkowitz 2002: 20–21). Rogers conceived of a science-based university committed to the industrial development of the Boston region in which it was based. With funding from philanthropists, local industrialists, the local state, and federal government land grants for Massachusetts, Rogers pursued his idea of creating a ‘technical intelligentsia’:

He was contemptuous of ‘blind experimenters’ who cluttered up the patent office with useless devices by attempting to make technical improvements without knowledge of physical laws. Rogers believed scientific training was required to produce inventions of ‘real and permanent value’ and that there was no industrial art that could not be improved upon through a systematic understanding of natural laws. (Etzkowitz 2002: 22)

Here were some core building blocks of MIT research: understanding rooted in rigorous empirical investigation, and its industrial art application. However, it is my view that this involved a relative concentration, up to the 1920s, on PAR – a focus on practical solutions to specific local industrial problems in context, albeit based on careful experimentation as per Rogers’s philosophy. Only after 1930, under President Compton (a scientist, not an engineer), when its engineering research became more closely linked to the natural sciences, did the research become more strongly driven by advanced scientific theory. I would argue that it was at this time that a relative concentration on UIBR began to emerge.

Etzkowitz suggests that MIT had developed by 1900 as a unique university ‘with strong engineering, science and humanities specialities’ (2002: 21) – compared to the historical centrality of the arts and natural sciences at its university neighbours, Harvard, Princeton and Yale. Its founders laid this basis with a vision of ‘systematic understanding’ linked to degree programmes that would separate the institution from more practically oriented technical colleges (such as the neighbouring Lowell Institute) and from more applied engineering schools like the Rensselaer Polytechnic Institute (New York) and West Point (with its military specialisation in civil engineering) (Etzkowitz 2002: 21). In other words, from its early days its focus on PAR nonetheless had a significant ‘scientific knowledge’ foundation.

Etzkowitz (2002: 20) identifies four building blocks of MIT. From the beginning, the university had a classical undergraduate college teaching focus, like other American research universities. Development based on the European polytechnic movement, including the German Technische Hochschulen, provided the second building block.
(Etzkowitz 2002). The third block was the American land grant system: following the federal law of 1862 (the Morrill Act), federal lands were provided to each state in the USA for the establishment and maintenance of state universities, ‘where the leading object shall be, without excluding other scientific and classical studies…to teach branches of learning as are related to agriculture and mechanical arts’ (quoted in Geiger 1986: 5). In some respects, therefore, MIT was simply an ‘industrial’ rather than ‘agricultural’ land grant university.

These three blocks all facilitated the vision, noted above, of the creation of a technical intelligentsia. But it was MIT’s growing identity as one of what Geiger (1986) terms the small elite group of American ‘research universities,’ according to Etzkowitz, that provided a fourth and crucial building block for the institution. I would add that this additional vision of MIT, which grew in strength after 1900, to identify itself with the elite American universities that had emerged in the last quarter of the nineteenth century was fundamental in facilitating its shift towards UIBR after the 1920s. This is highlighted by the fact that MIT only officially joined the ranks of this group of 15 or so American research-intensive universities in the 1930s – something not stressed in Etzkowitz’s narrative.

The roots of MIT’s identification with these ‘research universities’ lie in the establishment of its first graduate school in the early 1900s. This, I would argue, should be viewed as MIT initiating its first academic transformation: developing research in association with postgraduate training, and thereby granting its second mission of research equal status alongside its earlier mission of (mainly) undergraduate teaching. This transformation, linked to PhD training and its graduate school, came some decades after a similar first academic transformation had taken place among the ‘elite group.’ To understand how important this was for MIT in the early 1900s, and how it laid the foundation for what I call its ‘post-1930 UIBR enhancement’, it is relevant to digress briefly into the story of how this transformation at American elite universities occurred in the last quarter of the nineteenth century.

From the 1870s to the 1890s an internal transformation of research-cum-PhD training took place in (initially) 12 elite universities in America. Geiger (1986: 7–8) argues that it is generally not appreciated how important in this regard was the founding in 1876 of Johns Hopkins University as a postgraduate institution. He cites Edward Shils, a leading scholar of American higher education: ‘The foundation of Johns Hopkins University was perhaps the most decisive single event in the history of learning in the Western hemisphere’ (Shils 1997: 13–14). This graduate-school university was the spark that set in motion a postgraduate ‘movement’ and, to use Etzkowitz’s term, a first academic revolution of ‘research mission’ linked to this.

Up to the 1870s all the elite colleges (Harvard, Yale, Princeton, and so on) had been almost entirely undergraduate ‘colleges,’ focusing on a broad liberal arts curriculum for training ‘gentlemen’ along Oxbridge lines (Geiger 1986: 3). But change could not be held back after the Civil War of the 1860s, particularly, I would argue, because the emerging industrial capitalism of the 1870s and 1880s (the ‘second
capitalist industrial revolution’) demanded new forms of research and, especially, the professional training of university students. Another factor was that groups of American scholars were returning from PhD training at high-quality German research universities, which had been undergoing a first academic transformation of research development since the Humboldtian revolution of the early 1800s.\textsuperscript{15}

The founding of Johns Hopkins as a postgraduate university began a process across the elite undergraduate colleges (partly because at least five Harvard faculty members seriously considered moving to Johns Hopkins, but were retained with the establishment of graduate education) that included the establishment of PhD programmes, linked to a new emphasis on faculty research (Geiger 1986: 9). The transformation occurred at older colleges such as Yale and Princeton, and at some newer institutions such as private universities (e.g. Cornell in 1868 and Chicago in 1892) and state universities (Illinois in 1867 and California in 1868). By 1900 what I would term the ‘core sociological elements’ of a first academic transformation research structure had emerged among this elite group of research-intensive universities:

- The departments were discipline-based (these were new disciplines such as physics, economics and history).
- They spanned both undergraduate and postgraduate levels, with the latter focusing on PhD training linked to staff members’ research.\textsuperscript{16}
- The discipline-based departments were networked together across universities nationally, through the emergence of discipline-specific journals (for example, the \textit{American Chemical Journal}, 1879, at Johns Hopkins, and \textit{Harvard Historical Studies}, 1896) and national discipline-based associations (such as the American Mathematical Society, 1888, and the American Economics Association, 1885).\textsuperscript{17}

The discipline-based journals and associations helped to cement the new research mission of elite academic departments across America. Moreover, according to Geiger, the formation in 1900 of the American Association of Universities (AAU), comprising 12 elite research universities, ‘signified that the research universities had become a self-conscious group within American higher education…[where the essence of a research university] was then held to be higher learning, graduate education, and the advancement of knowledge through research’ (1986: v).

By 1900 such universities had therefore undergone Etzkowitz’s ‘first academic revolution’, joining basic research-cum-PhD training to traditional undergraduate teaching. These 12 were shortly joined by two others, although – significantly – MIT (and Caltech) did not follow suit until the 1930s (Geiger 1986: v, 19). The long-term impact of the high-quality research being done at these 16 institutions, later joined by many others\textsuperscript{18} – making the USA the leader in technological innovation and the global economy by the mid-twentieth century – is considered in Chapter 3. Here, however, we turn again to the MIT story and the important transformations it underwent in the direction of UIBR in the decades between 1900 and 1934, when it finally joined the ‘research elite of 16’ within the AAU.

Despite the emergence of graduate-school education at MIT from the early 1900s, it is my view, as indicated earlier, that until around 1930 the orientation of MIT
was primarily towards PAR. Of note is that the first graduate school at MIT was in engineering research, complementing research already under way in physical chemistry in the early 1900s, and its first PhD was not awarded until 1907 (Geiger 1986: 18). Around these areas emerged an interesting clash between two leading professors at MIT, Arthur Noyes and William Walker, which, I suggest, well illustrates the dominance at MIT of PAR rather than UIBR in the period up to the end of the 1920s.19

In 1903 Noyes had founded MIT’s first research laboratory of physical chemistry, oriented towards pure research. He was an alumnus of MIT who had returned to join the faculty after completing graduate work in Germany. Walker had been a member of the faculty since 1894, dividing his time between MIT and a consulting company. In 1908 he became full-time director of the laboratory of applied chemistry (Etzkowitz 2002: 30). A clash ensued within the Department of Chemistry and Chemical Engineering between what was viewed as a basic science approach and an applied science one.20 The significance of the quarrel went far beyond the department: ‘The two laboratories represented different visions for the future of the Institute’ (Etzkowitz 2002: 30).21 These different visions are succinctly captured by Servos (1980). He argues that ‘Noyes’s position was grounded in the conviction that advances in applied science and engineering were predicated on training in the fundamental sciences and experience in basic research’ (Servos 1980: 534).

In terms of Stokes’s categories, this would essentially involve an emphasis by MIT on UIBR. In contrast, I would argue that Walker was placed firmly in the PAR category:

Unlike Noyes, Walker and his associates did not believe that greater stress on the fundamental sciences was the essential ingredient for shaping useful and creative engineers. Of course, the engineer must be acquainted with the principles of the physical sciences, but Walker felt it would be a mistake to organize the entire curriculum around such studies…It was only through exposure to problems drawn from industry that the student could learn the uses and limitations of theoretical chemistry. (Servos 1980: 535)

Leading academic administrators, from the president of MIT to the head of its chemistry and chemical engineering department, tried unsuccessfully to reconcile the two approaches. After the First World War, when Walker threatened to resign, he forced MIT to choose:

Noyes, the director of the theoretical laboratory, was placed in an untenable position and resigned. He went to California where he played a leading role in reorganizing the Throop Manual Training School into the California Institute of Technology, according to his ideas of emphasizing fundamental research. With the departure of Noyes, the Massachusetts Institute of Technology affirmed its founding mission of concentrating on technology and developing relationships with industry. (Etzkowitz 2002: 30)
In reviewing the Noyes–Walker clash, Geiger (1986) argues that industrial funding was certainly a factor in Walker’s eventual support by the MIT leadership. Yet drawing on Servos and others as sources, he goes on to argue that during the 1920s the growing volume of industry-linked research activity at MIT did not in fact contribute appreciably to the prosperity of the institution. On the contrary, the temporary nature of industrial contracts caused workloads and staff to fluctuate irregularly. In addition, an ambitious technology plan initiated in 1919 to obtain endowments from regional industry in exchange for applied research services, did not draw the expected finances. Yet when some industry funding was forthcoming, an additional problem emerged for MIT: on several occasions ‘researchers were prevented from publishing discoveries made under industrial contract’ (Geiger 1986: 180). Throughout the 1920s there was also a persistent complaint that industrial research ‘too often concerned trivial development problems’ (Geiger 1986: 179). In Part 2 of this book, when investigating the Western Cape research groups, I term this the ‘problem of routine consultancy work’ (a term already introduced above, referring to investigative work with no new knowledge – that is, research – components). However, according to Geiger, by the 1930s it ‘…became the general policy of the institute [MIT] that routine scientific work would be directed to commercial [private company-based] laboratories. MIT would undertake only research touching upon important research questions that required the special capabilities of its faculty and facilities’ (1986: 182).

This quotation from Geiger suggests that an important shift had taken place by the 1930s. Why was this so? The discussion below shows that this shift was significantly linked to the appointment of a new MIT president in 1930 – a scientist chosen specifically to deal with the problems just noted in engineering-science at MIT in the 1920s.

**MIT and the 1930s shift towards UIBR**

The reorientation effected by new MIT president Compton did not turn MIT’s primary focus towards PBR, despite his theoretical physics background; instead, I suggest the shift he facilitated was towards UIBR. Geiger (1986) and Etzkowitz (2002) both note this shift towards more basic research under Compton, but neither clearly distinguishes PBR from PAR through the intermediary concept of UIBR.

It was thus no accident that MIT joined the small elite of research universities within the AAU in 1934; Geiger (following Servos 1980) relates this development directly to the appointment in 1930 of a top physicist as president: ‘The selection of the new president of MIT symbolized the beginning of a new era in the relations of industry and university science. The man chosen to bring about the reorientation of MIT was Karl T. Compton, the forty-three-year-old head of the Princeton physics department’ (Geiger 1986: 181).

Interestingly, the decision to offer him the presidency of MIT seems to have come from the presidents of the General Electric Company (Gerard Swope) and Bell
Telephone Laboratories (Frank Baldwin Jewett), who seem to have realised the need to link engineering more strongly with basic science: 'It was Jewett who actually persuaded Compton to accept, by stressing the obsolescence of traditional engineering education, locked into teaching of immediate practical skills. As the leading institution of engineering education, MIT had a responsibility, according to Jewett, to introduce fundamental science into engineering' (Geiger 1986: 181).

In the 1930s Compton set about enhancing MIT as a research-intensive university, joining the elite club of the AAU and drawing on support from national (federal) and local (Boston region) government, as well as from national and local industry. He also tapped a funding source that had been vital for the other research-intensive universities: private foundations such as the Carnegie Corporation and the Rockefeller Foundation (Geiger 1986: Chapter 4). For example, immediately on his appointment, Compton approached the president of the Rockefeller Foundation, which had earlier been reluctant to fund an ‘applied science’ institution such as MIT, stating explicitly his commitment to effecting a shift towards more fundamentally oriented research:

I know, that your [Rockefeller] Board is sympathetic with the principle that increase in fundamental knowledge is of basic importance...It is of course known that my selection indicates a wish on the part of the Corporation [the governing body of MIT] to emphasise this line of development [based on fundamental science]. Immediate substantial evidence of approval by the Rockefeller Foundation [of the soon to be granted US$170 000 for MIT research] would have a psychological effect of putting this programme [Compton’s mission to enhance research] on a firm and accepted basis.

(Quoted from a 1930 letter from Compton to the Rockefeller president, in Servos 1980: 545)

With support from such foundations, Compton ‘appointed outstanding scientists, including former colleagues from the physics department at Princeton’ (Etzkowitz 1993: 336). By 1937 MIT was ranked among the top three physics departments in the country (Geiger 1986: 183). But, as importantly, Compton set about implementing his overall programme by linking engineering not only to physics, but also to pure mathematics and theoretical chemistry: ‘Compton was convinced that the future of [MIT] depended on strong science departments. He brought in 30-year-old John Clark Slayter [from Harvard] to head the physics department and encouraged chemistry and mathematics to widen their horizons’ (Schweber 1992: 159–160).

It should be stressed, moreover, that this attempt to enhance basic chemistry at MIT was itself linked to the fact that American chemical engineering by the 1930s was experiencing a shift away from the ‘Walker orientation’ towards the pole that Noyes himself had advocated two decades earlier:

No longer content to prescribe means of improving industrial procedures, chemical engineers now wished to quantify and extend their knowledge of such topics as heat transfer and exchange, high temperature and
pressure reactions, and gas absorption. These studies, while growing out of problems encountered in industry, often led investigators far from the realm of immediate practicable technology. (Servos 1980: 543)

The points made by Servos capture the core issues of my arguments regarding the transformation of MIT in the 1930s towards a greater emphasis on UIBR:

Although he [Compton] did not put an end to all sponsored research and consulting activities, he did place controls on such work; moreover he laid new stress on the importance of research and training in the basic sciences. In formulating his policies, Compton pursued a goal Noyes had earlier advocated, that of making MIT into a science-based university. (Servos 1980: 548)

To conclude this section, I make brief reference to some of the controversies and controls surrounding the developments of research at MIT in the 1930s – issues pertaining essentially to what I have termed ‘use-oriented research’ (UIBR + PAR). It is appropriate to note these here, since it will be seen in Part 2 that such controversies are impacting increasingly on Western Cape universities, as they begin to incorporate a third mission into their research activities.

During the 1930s Compton had to deal with the diverse problems and consolidate the practices arising from MIT’s ‘third mission’, in relation to issues such as consultancy work, the ownership of knowledge and patents, and spin-off companies linked to regional economic development. In an interesting set of chapters on such questions, Etzkowitz (2002) argues that in dealing with these issues through various compromises before the Second World War, MIT learned how to institutionalise and thereby normalise the third mission. For example, there was the controversy over consultation. This, as noted above, had already emerged in the 1920s, but it grew more acute because of the stress on high-quality academic research publications and PhD training, which increased under Compton. The controversy involved some of the most prestigious professors, including Vannevar Bush (Etzkowitz 2002: 37). It was also linked to the fact that for some decades MIT had sought to recruit the most outstanding engineers in industry to become professors at the university (Etzkowitz 2002: 33). The work of these engineers had been research-based while they were still working in industry, and they wished to continue to link their scholarship to their industrial consulting work while at MIT. Some professors at MIT opposed this practice, arguing that it would weaken the commitment to teaching, while others saw it as likely to be detrimental to academic research (Geiger 1986: 181).

For some decades MIT had no clear policy on this matter, which led – as with most academic controversies – to the establishment of a committee that met on and off for about 20 years (Etzkowitz 2002: 38). Eventually, in the early 1930s under Compton, the committee established the ‘one-fifth rule’ – a compromise position now taken for granted at American research universities. According to this rule, a professor may do industrial consulting one day a week. It should also be added – and this is omitted in Etzkowitz’s narrative – that Compton ‘instituted a set of guidelines on faculty...
appointments, promotions, and compensation that put a premium on original research and discouraged excessive consulting work’ (Servos 1980: 547). Moreover, new policies ‘specifically forbade staff members to accept research work that could be handled by private consultancy firms’ (Servos 1980: 547).23

In this way, already in the 1930s, MIT developed procedures to deal with questions of research-based consultancies which – as will be seen in some of the case studies in Part 2 – would become controversial issues linked to growing third-mission research activities at South African universities after the 1990s. Expressed in the terms used by Prof. Q (Case 3 of the Western Cape), quoted in the Introduction to Part 1, MIT had by the end of the 1930s worked out ways of putting an ‘artificial wall’ between the research-intensive work in its laboratories, and the more routine R&D work in the laboratories of industry.

Etzkowitz (2002: Chapter 6) describes a similar controversy that emerged over patenting. He suggests that, once again, a MIT committee resolved the issue by means of a compromise; and in the 1930s a set of patenting policies emerged incorporating the ‘gains’ to be accrued by both MIT and individual academic inventors at the university. These pre-date by nearly 50 years the institutional policies and practices regarding IP that emerged from the 1980 Bayh-Dole Act, which is concerned with rights to IP emanating from federally funded research (Mowery et al. 2004).

According to Etzkowitz (2002: Chapter 7), MIT was probably also the first university to deal, in a substantial and systematic way, with its third mission role in regional economic development. Even in the mid-1920s, the New England Council had been formed by industrialists and political leaders seeking solutions to economic challenges in the Boston region, and together with MIT they tested some research ideas for economic development. However, nothing much came of these proposals or of others in the 1930s driven by Compton. Etzkowitz suggests that they were embryonic ideas, which awaited a more favourable future climate. They were the seeds, he argues, of the present-day Boston technological corridor – the Route 128 complex on the east coast that parallels Silicon Valley on the west coast (see Etzkowitz 1993 for additional details). Nevertheless, it should be noted that a ‘new products committee’ – organised in 1939 by the New England Council on Compton’s initiative to investigate the development of new products in the region, on a basis that included mobilising university research resources – did begin to develop a concept of ‘spin-outs’ of technical firms from university-based research. Etzkowitz (2002: Chapter 8) argues that these ideas laid the basis for the ‘invention of the venture capital firm’ after the Second World War, with key members of the pre-war committee and its subcommittees leading the process after the war. This pre-dates by some decades the developments in the 1980s that will be described in the next chapter, which saw the massive growth of a third mission at universities in America, with venture capital firms becoming linked across a wide range of disciplinary fields, and biotechnology providing a cutting edge.
In summary, this discussion has highlighted the enhancement of UIBR and some controversies around it at one institution – MIT under Compton – from the 1930s to the end of the Second World War (and beyond under subsequent presidents). Or, as Geiger has put it: ‘The new [1930s] course did not sacrifice the great prowess that MIT had developed in engineering education and research, but instead combined it with a renewed emphasis on basic science. This was a combination of enormous potential’ (1986: 183).

The crux of my argument has been that MIT underwent a high-quality second academic transformation before the 1940s. However, I would suggest that, if one considers the broader national academic science scene of America at that time, the Second World War can be seen as a very important turning point with regard to Pasteur’s Quadrant of UIBR at research-intensive universities. The war gave rise to new U–I–G research relationships at the national level, and the discussion now turns to the link between UIBR and the American war effort.

An academic turning point: The Second World War and UIBR in the USA

1939: New ideas about university research

The Second World War ushered in a new U-G relationship, linked, I suggest, to a turning point in human society in terms of the relationship between scientific theory and technology. Stokes has written of this: ‘It is difficult to exaggerate how profoundly the relationship between science and [the US] government was transformed by World War II’ (1997: 45).

A comparison between the First World War and the Second World War makes this clear. Basic science knowledge was not entirely absent during the war of 1914–18, in the form of gas warfare, bombs, mortars across trenches, and so on. However, the physical side of trench warfare and its associated tactics were still central: it was not unlike the wars of the previous century, when cavalry and infantry charges and associated weapons (horse, rifle, cannon) were still at the core, and was not based primarily on fundamental scientific theories. The use of aeroplanes was in its infancy. Geiger concedes that some American university scientists contributed through solving problems of production and supply, refining existing weapons and even tracking enemy submarines, but he concludes, probably over-generously, that in the First World War ‘their record for fundamental discovery and invention was comparatively modest’ (1993: 4).

But the war of 1939–45 was different: aircraft warfare and bombing, radio and radar and submarine engineering, and finally the atomic bomb, would all have been impossible without the underlying basic science (Sapolsky 1977). Schweber gives the example of a leading physicist working on microwave propagation in 1942 who described his work ‘not as war research but rather as fundamental research which may serve as the basis for directly useful investigations’ (1992: 171).
I would suggest, then, that fundamental science became fundamental to success in the Second World War. Moreover, if one compares the roles of basic science in the First World War and the Second World War, one can see both quantitative and qualitative differences in how academic scientists were drawn, organisationally, into each war. In the First World War, university professors were absorbed into military laboratories in a relatively minor way, under military control and under military research guidelines:

During World War I, the military directly utilized the educational capabilities of the universities but not, to any great extent, the research capabilities. Thus, World War I had relatively little effect on MIT [for research development] other than the use of its facilities as an officer training school...[The] military continued its policy of conducting its research in-house at its own establishments. (Etzkowitz 2002: 46)

However, during the Second World War, as described further below, significant numbers of leading university scientists were involved, often in new and larger forms of research organisation that might be viewed as prototypes of present-day research ‘centres’ or ‘institutes’. Within these new, loosely constructed research groupings, professors controlled the research guidelines for military technology – usually within university-based laboratories, though linked both to industrial manufacturing company research contracts for the war effort, and also to the military and government leadership. A complex set of new modes of U–I–G research relationships was emerging, which Etzkowitz (2002: Chapter 4) identifies clearly in his discussion entitled ‘Traffic among MIT, Industry and the Military’ during the Second World War.

One should add to these points of Etzkowitz’s that the type of research being undertaken within the in-house military laboratories during the First World War was mostly PAR, with not many new theoretical science elements. But two decades later, at the beginning of the Second World War, things were very different: leading American scientists quickly realised that basic science – in my view (and Stokes’s) actually UIBR – was going to be crucial to the war.

Stokes himself argues that in 1939, before the war, a group of leading American scientists clustered around Vannevar Bush understood the central role that basic science was about to play: ‘Bush and his colleagues understood better than [American president] Roosevelt that the coming war would be partly a scientific and technological conflict’ (Stokes 1997: 46). The ‘Bush and his colleagues’ that Stokes refers to were five academic leaders, all of whom were outstanding scientists: Bush himself, Compton as president of MIT, Conant as chemist and president of Harvard, Jewett as president of Bell Telephone Labs and of the National Academy of Scientists, and Tolman as dean of the graduate school of Caltech. In 1940 Bush and his colleagues presented Roosevelt with a one-page proposal urging the creation of a National Defense Research Committee (NDRC). A year later the NDRC was established as part of a new Office of Scientific Research and Development (OSRD), with Bush as head, in the executive office of the American president (Stokes 1997: 47).
The NDRC began driving forward research for the war effort primarily by contracting out research projects to university-based labs, which were linked to industrial equipment-manufacturing companies—all with massive funding from government. A triple helix national research framework was thus in the making.

Changing modes of research organisation and processes, 1940–45

Before the Second World War, many American scientists had in fact been passionately against accepting federal funding, primarily because of a fear that the government would ‘direct and control the research.’ The dominant academic view was in support of a clear separation of pure and applied research, with the ideology of ‘the ideal of pure enquiry’ strongly prevailing within research-intensive universities. Yet, to pursue the war effort, they realised that new U–I–G relations were needed, leading Stokes to point out that, ironically, Bush’s OSRD became ‘the nearest thing to a true central science organization in all of American history’ (1997: 46, quoting a science analyst).

I would argue that insights emerging from a close look at the organisation of research during the Second World War under Bush’s OSRD are of central importance. Here one can observe, in embryonic form, new research centres and other forms of research networks. These new, larger modes of research organisation functioned more efficiently in providing the UIBR and PAR that were necessary to achieve the high-level, science-based technology relevant to the missions of the war effort.25

A radiation laboratory was established at MIT and a few other laboratories were set up ‘at half a dozen universities’ (Etzkowitz 2002: 48). The highest-quality research for the war was thus concentrated at only a few sites of scientific excellence, clustering together larger numbers of scientists in each case. As already noted, these laboratories were located on the campuses under a complex combination of research control and guidelines applied by the academic scientists, who worked closely with the relevant military officials, engineers and other support staff. I would suggest that a central reason was undoubtedly an implicit understanding that such UIBR could develop best when clearly under the control of the academics themselves.26

It seems clear from the data provided by Etzkowitz (2002: 51; see also Etzkowitz 1992, 1994) that there was a qualitative shift at this time, from ‘little science’ in which one professor worked in a lab alongside a few post-docs, PhD students and other assistants, to the ‘bigger science’ of a research centre, or even a broader network of centres and units. Here, too, Geiger provides valuable data to support my hypothesis of the growth of larger centres or networks of research units:

The system of contract research [OSRD contracting out to labs] did not result in many university scientists spending World War II in their own laboratories; for the most part they spent the war in someone else’s lab. A large portion of the nation’s active physicists, whose experience was in greatest demand, had relocated before Pearl Harbour.27 The subsequent
acceleration of war research confirmed this trend...In general, the larger the
research projects, the greater the break with the kind of research
arrangements that the universities were accustomed to. (1993: 7)

As one example, Geiger describes the MIT radiation laboratory – known as the ‘Rad
Lab’ to mask its true purpose – which in 1940 had been contracted at MIT by the
microwave committee of the NDRC under Bush’s OSRD. The Rad Lab was set up to
study high-frequency waves for the development of radar equipment, manufactured
under development contracts by industrial firms as part of the research teams of
U–I–G networks established for the project. Geiger explains that MIT was chosen
because ‘nowhere in American higher education were the basic scientific disciplines
and the application of science through engineering more closely intertwined’ (1993: 9).

By the end of the war the MIT Rad Lab had developed 150 different radar systems –
despite the initial scepticism among the scientific old guard about concentrating
so many academic scientists in one lab (Geiger 1993: 10). As noted by Etzkowitz
(2002: 52), the Rad Lab grew from an anticipated 50 persons at its inception in 1940
to 3 897 personnel – including 1 189 scientists and engineers – by the end of the
Second World War.

Geiger (1993: 10) makes an additional important point that although the original
Rad Lab was located at MIT, it was not really ‘of MIT’. From 1940 on, most of the
key scientists had come in from other leading research universities; in fact, only
one MIT professor was represented on the first steering committee of the project.
What I would suggest, therefore, was that what was happening in effect was the
construction, within the Rad Lab, of a large ‘centre of research’ – with each professor
(usually not from MIT) creating his own subgroup of researchers, engineers and
other personnel, and with this group often being linked to other professor-led
subgroups. As the Rad Lab grew larger there emerged a ‘collection’ of centres, and
substantial networking developed between research groupings within the Rad Lab
and other research groupings at neighbouring and even distant universities. This was
not unlike the EU FP6 described in Chapter 1, with its attempts to develop what it
calls NoEs – about 60 years later!

As well as the few larger, Rad Lab-type enterprises linked to the war effort that
emerged at some other universities, many smaller wartime research projects
were contracted out via the OSRD system of decentralisation that put out projects
to the universities. This resulted in a myriad of ‘little science’ units – a vast array
of individual professors working with only a few research assistants – emerging
parallel to the growth of the larger centres (Geiger 1993: 11). As I hypothesise later
with reference to the Western Cape case studies, we observe here a complex set of
‘model types’ of use-oriented research across the universities. These included new,
larger centres (what I termed Model A centre types in the Introduction to Part 1) and
networks of professors (Model C ‘virtual centres’), alongside and parallel to a series
of small research units (Model B ‘little-science’ types).
Geiger notes the importance of the Manhattan Project to develop the atomic bomb, which comprised the largest and newest research organisational structure of all, bigger even than any of the ‘collections of centres’. Initially this project involved a dispersed network of professors and their teams working on diverse problems at different universities, but at a later stage the whole project was centralised as a massive research-cum-industrial undertaking at the Special Weapons Laboratory in Los Alamos, New Mexico. At its peak this comprised, in addition to thousands of support personnel, about 1 200 scientists and engineers, including at one point eight Nobel laureates. It was so large, and so expensive, that only the government could fund it (Geiger 1993: 7–9).

It seems clear, therefore, that numerous American professors of basic science became part of UIBR missions for the war effort after 1939. To achieve their goals – particularly for efficiency reasons – they were forced to enter new types of research organisational modes: research centres, networks of centres or units, ‘collection of centres’ and even, in the case of the Manhattan Project, an enormous laboratory complex. They worked alongside teams of engineers, technicians, administrators, financial officers and personnel from manufacturing companies, in a mode that was a far cry from the small, individual-professor lab unit with a few post-doctoral students, some PhDs and a technician or two, with which many of them had been familiar in the pre-Second World War era.

In Chapter 3 some theoretical aspects of this change towards larger modes of research organisation will be explored. But it is useful to end this brief discussion of university research during the Second World War by noting two other points. Firstly, as argued by Etzkowitz (2002: Chapter 4), some of the new research modes and practices developed during the Second World War did have a precedent in a university such as MIT, which, by the 1930s under President Compton, was already enhancing its own triple helix relationships. Thus MIT developments in the 1930s did provide some models for the wartime transformations.

Secondly, Etzkowitz’s story shows that wartime research under the OSRD focused on fields such as electronics, nuclear physics, chemistry and other natural science–engineering subfields perceived as relevant to military problems. Medical research for the war effort (not the focus for Etzkowitz) became organised during the Second World War by a separate Committee of Medical Research, which was parallel to the NDRC, with both falling under Bush’s OSRD (Geiger 1993: 6). This medical research, which was important during the war and grew significantly in importance and funding afterwards, included components of UIBR, which became increasingly important within medical fields in the latter part of the twentieth century. But what is equally interesting, I would argue, is that except for the occasional mention of psychology, the social sciences such as sociology, political studies and even economics hardly feature in these descriptions of wartime science by Geiger, Etzkowitz and others – perhaps because the OSRD did not yet appreciate the potential role of social science research work for the war effort. The issue of a
broader third university mission of socio-economic–cultural development, which should include the social sciences and other related disciplines in the twenty-first century, will be taken up in later chapters.

**Strengthening university PBR, UIBR and PAR in the USA after 1945**

After the Second World War, Bush and other leading American scientists sought to roll back the federal government control mechanisms over academic research that had begun to emerge via the OSRD. They wanted, nevertheless, to sustain the levels of federal funding, which had increased so much during the war. In other words, like most professors, they wanted to have their cake and eat it! Stokes has thus pointed out, as already noted in the first section of this chapter, that when Roosevelt invited Bush to develop proposals for a post-war national research system, Bush’s 1945 report *Science, the Endless Frontier* strongly stressed the need to maintain the ideal of pure enquiry through the autonomy of basic research, to be funded without concern for practical ends. At the same time, through his propagation of the linear research model, Bush was able to promise potential government funders that American basic research would eventually lead to applied research (and hence technological innovation), while maintaining the rigid ideological separation of ‘pure basic’ from ‘pure applied’ research (Stokes 1997: 50).

At American research-intensive universities during the two decades after 1945, Bush’s vision of ‘unconstrained pure science’ – at an ideological level – achieved success by becoming accepted and consolidated in the minds of most academics, according to Stokes. Yet, ironically, the picture regarding practices on the ground within universities was much more complex. For, as argued by Crow and Tucker, whereas Bush and many other scientific leaders who followed in the decades after 1945 sought to establish basic research funding as a federal government priority, what actually happened was that such funding ‘contributed to the massive growth of a wide range of research capabilities (basic, applied, fundamental technology development, and so on) within American research universities’ (Crow & Tucker 2001: 6).

One can see the complex interplay between PBR, UIBR and PAR – contributing to such a wide range of research capabilities – by looking at the role of military funding of American university research after the Second World War, particularly at the elite research-intensive universities. This was especially important because, until federal government funding began to take off later in the 1950s – after the new NSF (established in 1950 with a focus on basic research) and other federal funding agencies became more established – the funding of components of basic research by military agencies was very important for American universities. The creation of the Office of Naval Research (ONR) in 1945, concurrent with the phasing out of the OSRD at the end of the war, provides an interesting example of the indirect contribution of the military to an array of research modes. According to Stokes, the ONR immediately ‘launched a vigorous program of support for basic science,
becoming in some respects a “National-Science-Foundation-in-waiting”...[and the] ONR’s deputy director and chief scientist later became the founding director of the National Science Foundation’ (1997: 52). Stokes mentions further that ‘an enterprising reporter for Fortune magazine went to a meeting of the American Physical Society in spring 1948 and found nearly eighty per cent of the papers were supported by the Office of Naval Research’ (1997: 53). Clearly, therefore, the American military had no doubts after the Second World War about the continued value of UIBR.

Another post-war example of the military acting to enhance UIBR and PAR can be found at MIT. Although the Rad Lab at MIT was disbanded as an operating entity at the end of the war, its theoretical division became the Research Laboratory for Electronics. It grew massively in the 1950s, with a separate ‘Lincoln Lab’ set up through a special federal contract explicitly for developing an early warning strategic radar system. Defence agency funding was so crucial to the Research Laboratory that Geiger describes it as ‘one of the central knots in a tangled skein of relationships between MIT and the military’ (1993: 67).

The Research Laboratory and Lincoln Lab spawned some 60 spin-off electronic firms (Geiger 1993: 67), while the physics department, too, was closely linked to such research. From 1946 to 1956 the physics department’s budget for academic staffing fell, even though the size of staff rose by one-third – because academic costs were cross-subsidised by contract research (Geiger 1993: 64).

These developments were often linked to forms of centre-type research organisation (which Geiger terms ‘organised research units’). These grew at MIT to such an extent that a census in 1978 identified 65 such units created since the Second World War, with 36 still in operation (Geiger 1993: 64). At least one, the Centre for International Studies, emerged in the social sciences. Associated with the political science department and partly funded by the CIA, it sought to solve ‘long-term problems of international policy which confront decision makers in government and public life’ (1979 MIT report, quoted in Geiger 1993: 68). Clearly, therefore, the social sciences were beginning to be drawn into the embryonic practices of a third mission linked to U–I–G relationships.

In essence, the Crow and Tucker argument (2001) cited above points to the fact that funding for PBR and also UIBR at American universities, in particular during the decades 1945 to 1975, laid a technological base that enabled the American economy to develop and expand significantly in the latter part of the twentieth century – or, in my terms, to ‘lift off’ into a third capitalist industrial revolution from the 1980s. This will be considered further in Chapter 3.

The discussion in the last section of this chapter turns to Stanford University, in order to illustrate some of the most crucial embryonic practices of institutionalisation of third mission university research and structures after the Second World War. These shifts towards a second academic transformation can be observed in selected academic fields, first in engineering science and then in some of the biosciences, well before the 1980s. Etzkowitz’s (2002: Chapter 9) narrative, which provides the
core of this section, shows how this transformation at Stanford just after 1945 was, in part, carried there by Frederick Terman, who had been one of Bush's electronic engineering PhD students at MIT in the 1920s. Professor Terman had observed the innovative potential of the research team mode of the MIT Rad Lab while he himself served as research director close by, at Harvard's Radar Counter-Measures Lab during the Second World War. After the war, Terman applied this mode at Stanford.

The consolidation of UIBR at Stanford after 1945

‘Applied’ electrical engineering and ‘pure’ physics

At Stanford University, the immediate post-Second World War period saw the flowering of some of the research systems and processes that MIT had initiated in the 1930s, and which had spread to certain American universities during the war (Etzkowitz 2002: Chapter 9). In the two decades after 1945, Stanford embedded and grew a combination of basic and applied research – what Stokes would term UIBR – primarily in the area of engineering-cum-physics. This was long before the flowering of UIPB in the post-1970s period, when fields such as ICT, biochemistry and the material sciences led the way in the second academic transformation in the USA.

By the 1930s there was already a flourishing regional electronics industry in the Stanford University area, linked in part to electronics programmes at the university (Etzkowitz 2002: 103); and, just before the Second World War, the Sperry company was involved with the Stanford physics department on klystron vacuum tube research for producing microwaves (Galison et al. 1992: 47).

Terman, often now referred to as the ‘father of Silicon Valley’, obtained his PhD under his mentor Vannevar Bush. Like Bush, he was ‘one of the few figures in the country working along the frontier between electrical engineering and physics’ (Geiger 1993: 119). In 1927 Terman returned to Stanford and soon became head of the electrical engineering department, and later dean of engineering. Etzkowitz argues that, although he never became university president, Terman was nevertheless ‘more influential than most presidents in shaping a new academic model’ (2002: 104). ‘Also like Bush,’ Etzkowitz continues, ‘Terman was active as a consultant to industry and participated, through his students, in forming new firms from technology developed at the university’ (2002: 104). In 1939 two of Terman’s PhD students were a Mr Hewlett and a Mr Packard, who he encouraged to form a firm based on their invention of a resistance-tuned oscillator (Etzkowitz 2002: 104) – clearly some of his students made a contribution to future developments! But in many ways Terman’s building of a new academic model, as noted by Etzkowitz in the quotation above, was more fundamental to his long-term contribution: this model embodied core elements of a second academic transformation.

It seems that Terman was quite conscious of what he was attempting to build up. As mentioned, he had observed first-hand the MIT Rad Lab during the Second World War while he served as research director at Harvard’s nearby Radar Counter-
Measures Lab, and he facilitated the creation of a similar radiation lab at Stanford after 1945. A clear sign of his post-war vision, according to Etzkowitz, was a letter he wrote in 1943 to a senior Stanford administrator:

By determining the proper fields on which to concentrate, and then really laying it on those selected spots, we can go places without needing large amounts of extra money. With twenty years, a suitable administrative basis, and reasonable backing from the President [of Stanford], it would be a pushover to do something really big. (Terman letter, quoted in Etzkowitz 2002: 108)

I would argue that this extract from Terman’s letter embodies most components of his new academic model.

Institutionalisation of Terman’s academic model in engineering sciences

In what might be called the first component of Terman’s model, the ‘proper fields’ of selection by him in engineering for ‘laying it on’ were closely linked in his mind to physics. For example, in 1945 under his direction, what was known as the Microwave Lab in engineering began as a division of the physics department (Etzkowitz 2002: 109). Although Terman hoped to gain industry funding for this and other labs, initially it was contracts from the navy’s ONR that drove this research forward, consolidated through a group of Stanford electronics research laboratories, so that by 1950 ‘Stanford was performing almost $500,000 of electronics research for the Department of Defense – about one-quarter of the university’s total research expenditures’ (Geiger 1993: 120).

At the outset of the Korean War (1950) such contract research for the ONR and others became focused at Stanford in what was called the Applied Electronics Lab – in part financed from a Hewlett-Packard donation. This lab was later merged into the Stanford Electronic Laboratories structure as a whole (Geiger 1993: 120), which graphically supports my argument that we see here the emergence, within larger research groupings, of a combination of basic science (physics) and applied science (electrical engineering) – UIBR *par excellence*. A study by Galison et al. (1992) of the Stanford physics department’s research after the Second World War supports this with empirical data: the Microwave Lab provided microwave power to accelerate electrons for nuclear physics research, but it also opened up numerous industrial applications, essentially providing ‘a bridge between Physics and Engineering’ (1992: 63).

A second component of the Terman academic model was the emphasis on long-term planning: Terman believed that universities very often lacked the ability to plan (Etzkowitz 2002: 109), and he determined to act differently over ‘twenty years’ – as is evident in the quotation above from his letter of 1943.

Associated with this was a third component: his attempt, as also suggested in the letter, to concentrate resources in only a few ‘selected spots’. This he sought to achieve not
only through a focus on physics–engineering, but also through his belief that research, not teaching, should take precedence in academic hiring decisions: he believed that several faculty members should be hired in the same subfield (for instance in microwave research). This was in opposition to departmental policies – prevalent at most American research universities at that time – of spreading faculty across a discipline within a department: ‘Terman based this strategy on the assumption that [faculty members] could teach more broadly than [only in] their research area. Thus, gaps in the curriculum that had to be filled for education purposes did not necessarily have to influence the hiring decision’ (Etzkowitz 2002: 105).

Terman’s leadership therefore helped to build up a concentrated set of research niches, with both theoretical and applied potential. In this way he also helped to develop ‘research CoEs’ at Stanford in the 1950s – what Terman himself termed ‘steeples of excellence’; only much later, in the 1990s, did these become the vogue internationally (Etzkowitz 2002: 105; see also my analysis in Chapter 3). One result of Terman’s model was a number of Nobel prizes for Stanford academics working in physics and electronics over the next few decades (Geiger 1993: 120).

This clustering of research niches was linked to the creation of a ‘technology pool’ within certain science-cum-engineering subfields at Stanford, and helped to facilitate Terman’s fourth component, the enhancement of U–I links, which played a significant role in the Silicon Valley development. Some of these academic subfields were selected for growth, in part because of an assumption that PhD students would be interested in these areas – for example radio and other electronic devices – in which graduates subsequently created spin-off firms (Etzkowitz 2002: 108). In addition, I would suggest that some of these subfields were areas that required a concentration of UIBR – for instance the physics of high-frequency oscillators in the design of multigrid tubes – thus encouraging certain firms and inventors to assign patent rights to Stanford as ‘custodian’ of the region’s knowledge base: ‘The rights to all of these electronic devices went into a common pool controlled by Stanford. Stanford’s repository of intellectual property was made available to all firms in the pool, allowing each company a broader base for product development’ (Etzkowitz 2002: 106).

A fifth component was based on the insights of Terman and others regarding the value of larger research teams, which had been emerging during the war – for example at MIT, including those in its Rad Lab. After the war Terman actively helped to formalise such clusters of research teams at Stanford – what I now conceive of as ‘real research centres’ (see Chapter 3). For instance, the Microwave Lab expanded with the creation of permanent research positions for staff. In relation to this lab, some professors were ‘released from all but essential teaching duties in the post-war period in order to concentrate on the development of centres’ (Etzkowitz 2002: 109; see also 2003: 114). I see this as marking the beginnings of a significant split between undergraduate teaching and research – an important characteristic of the second academic transformation (see Chapter 3 and the case studies in Part 2).
Etzkowitz mentions additional findings, which, I would argue, clearly show the development of new modes of research that go beyond the 'small science', single-professor lab with PhD students and a few post-docs. For example, in these new Stanford research centres (large labs) some professors were assigned full-time assistants to help manage their sizeable research teams, others were relieved of certain committee duties to facilitate more active involvement in their research, and additional funds enabled the hiring of technical staff such as mechanics, tube makers and radio technicians (Etzkowitz 2002: 109).

A sixth and final component of the Terman model relates to sources of funding. Despite Terman's assertion in his 1943 letter that 'we can go places without needing large amounts of extra money', it turned out that considerable financial support was needed: 'Terman initiated a three-pronged financial strategy that included: conducting defense-related research for agencies such as the Office of Naval Research; offering industry preferred access to research results; and developing some of the university's land as an industrial park and shopping centre to service the area surrounding the university' (Etzkowitz 2002: 110).

This combined set of elements, in effect making up a new academic model, prompted Terman to write in another letter as early as 1951: 'Stanford is now the most important centre of electronics among American universities. Although we cannot match MIT in size, we concede nothing to them in quality and in productiveness in proportion to the money expended by sponsoring agencies' (Terman Papers, quoted in Etzkowitz 2002: 110).

To summarise: my argument is that, by embedding UIBR structures and practices within certain science–engineering fields after 1945, Stanford was following pre-war MIT innovations as well as some of the new wartime practices which Terman himself had observed as research director of Harvard's Radar Counter-Measures Lab. Both of these universities institutionalised links with regionally based corporate industry and the federal government, including its defence agencies. Thus, within physics–electrical engineering at Stanford, a second academic transformation had been achieved to a significant degree, even before the 1960s. However, this transformation was almost entirely concentrated within a triple helix of U–I–G relations: the idea of academic departments linking up with a fourth helix involving non-government and civic bodies (such as local community organisations, trade unions and NGOs) seems hardly to have been raised, at least with respect to the players at MIT and Stanford described by Etzkowitz. This issue, which will be taken up further in Chapter 3, can also be linked to the third capitalist industrial revolution, which took off globally from the 1980s.

The 1970s: Institutionalising the second academic transformation in some biosciences

To end the pre-1980s story of Stanford, it is useful to comment on the evidence of Colyvas (2007) regarding the biotechnology transformation within some academic
fields at Stanford in the 1970s. Her case study focused on a life science department within the Stanford Medical School from 1968 to 1982, and I argue that we can observe, in the microbiology-cum-genetics subfield of the natural sciences at this university, clear practices and processes of the second academic transformation. One can infer from her study that, by the end of the 1970s at Stanford, not only had a third mission become well institutionalised within physics–engineering fields, but it had also begun to take root in some basic science areas linked to biotechnology. Thus Stanford before the 1980s was a leader, like MIT, of deep transformations in some natural science subfields:

Another key finding is that the early stages of the blending of industry and the academy in the life sciences [at Stanford] occurred long before the legislative mandates at the federal level in the 1980s [e.g. the Bayh-Dole Act of 1980], and the burgeoning of the biotechnology industry in the 1990s. (Colyvas 2007: 474)

A central concept in Colyvas’s life sciences case study is the idea of ‘institutionalisation’, the process by which – for a few leading life sciences American professors and their labs at Stanford – new practices and processes in university science-industry (U–I) relations became ‘normalised’. As she puts it: ‘Viewed processually, institutionalization represents the manner of attaining an order that, in turn, reproduces itself’ (Colyvas 2007: 458).

Colyvas shows that the new order in this basic science (non-clinical) department of Stanford’s Medical School was not by any means ‘normal’ in 1968, the start of the period that she investigates. She maintains that 1968 was also important because Stanford’s OTL was founded at that very time. Although an office of sponsored research already existed, the new OTL soon set about filing for IP protection and negotiating possible licensing arrangements with companies. Her study of the 1968–82 period at Stanford, she argues, ‘reveals a period when routines [of technology transfer, including IP] were underdeveloped, and considerable experimentation arose around appropriate ways to commercialize science.’ ‘I focus,’ she adds, ‘on the basic life sciences where patenting academic research was new and untested’ (Colyvas 2007: 457).

Up to the founding of the OTL in 1968, formal technology transfer procedures around IP at Stanford had been minimal. Moreover, nothing at all was ‘normal’ regarding technology transfer to an embryonic biotechnology industry in 1970 – the year when one of the labs in this department made its first ‘invention disclosure’. Yet, as mentioned in Chapter 1, the period from 1970 to 1982 saw 40 such disclosures by labs in the department, with millions of dollars of royalties flowing in from these disclosures over the next three decades (Colyvas 2007: 460). Colyvas also notes that in the 1970s ‘the magnitude of [subsequent] revenues was certainly not anticipated at the time by either the faculty or the university’ (2007: 474).

One of the most fascinating components of Colyvas’s analysis of this case is her exploration of how new routines were developed in the 1970s when ‘experimentation
arose around appropriate ways to commercialize science. Here was a life science
department founded by a Nobel laureate in the 1950s, with its focus in the 1960s
on excellent basic science, being mostly government funded – through the NSF
and NIH – at a time when ‘contract research was low, less than 2% of [research]
expenditures, and industry support was scant’ (Colyvas 2007: 459). Yet, in contrast
to this PBR of the 1960s, by the 1970s the labs in this department had produced
around 40 significant invention disclosures. I would argue that this embodies a shift
to UIBR. Interestingly, Colyvas mentions how the PI of one lab, a distinguished
senior scientist, refused to accept any personal royalties for himself, donating some
and putting a considerable amount back into the lab. By the 1980s, however, ‘taking
a personal inventor share’ of the royalties had become more ‘normal’ (Colyvas
2007: 472). Another issue that arose was whether a PI, or the researchers in the lab
or even technical staff (who were often at the cutting edge of the actual invention),
should be credited with the discoveries. In one disputed case, Stanford University
ruled that a post-doctoral student in one of these labs, who happened to be leaving
the university, was legally entitled to take her inventor income shares with her
(Colyvas 2007: 470).

In the 1970s a set of issues was thus emerging for which there were no clear academic
norms – issues in relation to basic bioscience becoming connected with industry
or, as Colyvas puts it, issues of how to ‘routinise’ (institutionalise) such processes. I
would, moreover, suggest that there is no better support for Stokes’s concept of basic
research as a component of UIBR than what one can infer from the content of a
letter mentioned by Colyvas in her analysis of a conflict between one of the labs and
a biotechnology company. This letter was from one of Stanford’s world-renowned
PIs, who pointed out very clearly to the company concerned that what he was doing
was basic bioscience with lucrative technological innovation consequences: ‘As I
see it, the gap between fundamental developments at university labs and [their]
practical application is now virtually nonexistent…I believe that industry does not
have the right to free access to information or material that is as yet undisclosed in a

The fundamental knowledge of this PI would have quickly translated, in the hands
of this company, into substantial profit!

Just as interesting is another comment in the same letter, which resonates with a
discovery I myself made – described later, in Part 2 – during interviews with one or
two scientists at research centres at Western Cape universities: that sometimes firms
acquire your best basic science knowledge not from your publications but from
‘innocent’ chats with you over lunch or during walkabouts in their firms, or from
your being an invited speaker at one of the firm’s seminars. Over resulting issues
of payment, Stanford’s top life science PI put it quite angrily: ‘I see no difference
between a paid consultant giving you this advice versus a purposely invited
speaker providing you with a key piece of information. Yet only the consultant will
be adequately compensated and protected in the event that something useful is
developed…’ (Letter of 1980, quoted in Colyvas 2007: 466).
It is useful to end this account with a summary of what Colyvas felt emerged from her case study of this early institutionalisation of policies and practices of technology transfer, linked to basic science research in the biosciences at Stanford during the 1970s. This was at least a decade before the institutionalisation of practices around a third mission – for the fields of biology, ICT, material sciences and, increasingly, other sciences – began happening at other American universities in the 1980s and, from the 1990s, at many universities globally:

The formation of Stanford University’s technology transfer programme in the life sciences…evolved from multiple models based on divergent definitions of invention, inventor, rewards, and university–industry boundaries. The eventual [technology transfer] programme that emerged [by the early 1980s] proved to be widely emulated [across American universities]. The norms of the academy [at Stanford] shaped the uses of resources and the conditions of their appropriation. In turn, the currency of industrial science prompted a rethinking of academic norms. (Colyvas 2007: 456)

To this can be added the findings of a study by Jong (2008) about the rise of biotechnology at Berkeley and Stanford. Jong shows how, at Stanford University, attempts by the biochemistry department in the 1950s and 1960s to effect a transformation of departmental divisions across the biological sciences within the Medical School were resisted by other academics. However, with the rise of the biotechnology industry from the 1970s, the period of the 1980s and 1990s saw a transformation in the organisational configuration of departments within the Medical School.38 Essentially, the process was driven by the Stanford biochemistry department which, by creating greater synergies with both clinical practitioners within the Medical School and biotechnology firms outside it, was able to effect a radical transformation of the departmental divisions across the biological sciences. By the 1990s microbiology formed the fulcrum of this cross-departmental transformation, with what I would term ‘previously PBR’ scientists now firmly associating their high-quality research with the biotechnology industry (Jong 2008: 1276–1279). In other words, the earlier 1970s embryonic developments at Stanford had by the 1990s become an academic transformation impacting on all the departments across the biological sciences.

This chapter has provided an overview of some important changes in academic research processes and organisational forms that took place from the 1930s to the early 1980s – first at MIT, then at certain American universities during the Second World War, and finally at Stanford – in which we can see the embryonic development of policies and practices of the second academic transformation and the associated third university mission. This transformation and new mission had at their core, at least within these two research-intensive universities, a practice of UIBR combining the highest level of basic scientific discoveries with technological innovation in an increasingly knowledge-based global economy. The next chapter begins by discussing a question not explicitly examined in this chapter: why did a
second academic transformation begin to take off at other universities in the 1980s – especially in America, and thereafter in the EU and some other countries?

Notes

1 At numerous other research-intensive universities (e.g. Cambridge in the UK or Chalmers in Sweden) one could also observe early features of a second academic transformation; but MIT and Stanford, and some Second World War developments at American universities, are focused on here, both because of the rich information provided by Etzkowitz and others and because in many ways they are the institutions that led the way before the 1970s.

2 In a footnote referring to the diagram on which this one is based, Stokes (1997: 163) explains that he uses the words ‘cell’ and ‘quadrant’ interchangeably in this context.

3 Stokes gives as an example of this some research for a book called Guide to the Birds of North America. My own example, from the social sciences, would be a scholarly biographical work, not driven by its usefulness or inspired by the quest for fundamental understanding (of, for example, general socio-historical processes), but nonetheless based on specific new knowledge, and hence embodying research.

4 Also of interest, regarding what he calls ‘Official Reporting Categories’ (Stokes 1997: 64), is his discussion of the OECD Frascati Manual. This manual was developed after 1963 by the OECD to collect country statistics on research activities and finances. Initially it used a simple binary division of research into either ‘basic’ or ‘applied’. Then, from the 1980s onwards, there was debate about whether to introduce a three-cell classification of research into ‘basic’, ‘strategic’ and ‘applied’. Stokes argues convincingly that, although the idea of ‘strategic research’ is an advance on the original crude two-cell division, it still does not fully capture the complexities of Pasteur’s Quadrant. (He notes that America’s NSF was still adhering to the two-cell division at the time of writing.)

It is my opinion that Stokes’s own concept of UIBR itself perhaps blurs subtle differences between ‘use-inspired basic research’ and ‘use-oriented basic research’. Stokes does note that his four cells actually blur the reality in that there are ‘many degrees of commitment to the two goals [of use and fundamental understanding]’ (1997: 72), but he does not pursue these issues further. Suffice to say here that Stokes opened up a central debate, which needs to be continued in order to develop more complex and nuanced categories than we have at present as Official Reporting Categories. And in this book, I shall for the sake of simplicity apply his concept of UIBR without introducing further subtle differentiations.

5 He cites, for example, the ancient Greek ‘ideal of pure enquiry’; a philosophy of divorcing enquiry from use which was carried into church-led feudal universities in Europe; and a social class separation within higher education in Europe between universities (focusing on ‘new knowledge’) and polytechnics (focusing on ‘applied knowledge’), which emerged with the industrial revolution. All these are certainly historical factors shaping our contemporary ideologies around these questions, which cannot be explored here.

6 In Science, the Endless Frontier, Bush (1945) went as far as asserting that ‘applied research invariably drives out pure’, that is, the two cannot be mixed (quoted in Stokes 1997: 3).

7 Bush’s linear model describes basic science as leading to applied research, which itself leads to technological development. Stokes (1997: 18–23) argues that this completely misses the new, more complex understanding of the science–technology interrelationship – in which
new technology often gives rise to new scientific understanding, and vice versa. In Bush's linear model, Pasteur's Quadrant is simply an empty cell.

8 In this approach, I shall be following the Frascati Manual definition of research as in essence 'new knowledge production' (see OECD 2002: sections 2.1, 2.2) which excludes routine testing and routine data collection, and thereby in essence excludes certain (non-research) work which involves investigation without any research/new knowledge components, that is, what I term here a form of 'routine consultancy'.

9 Crow and Tucker (2001: 6) describe this spectrum of new knowledge and innovation development as ranging from 'curiosity-driven basic research' through 'mission- (or use-) oriented basic research' to various forms of 'fundamental and not-so-fundamental' technology development.

10 The words of the first president, William Rogers; see Etzkowitz quotation above.

11 Until the 1870s, American universities ('colleges' at the time) provided almost exclusively undergraduate education (Geiger 1986: 3–4), hence the phrase 'going to college' used by American high school leavers to this day.

12 Etzkowitz notes that the Hatch Act of 1867 and the Smith Lever Act of 1918 built on the Morrill Act of 1862 by providing block research funds and then technology transfer and liaison capabilities for agriculture: 'The land grant universities helped make US agriculture the world leader' (2002: 25).

13 Here I have drawn particularly on Geiger (1986: Chapter 1) and Shils (1997) as well as on Etzkowitz (2002: 10–12, 27–28). For American higher education history in an international context, see Perkin (1997). Cooper (2006) considers the importance of the first academic transformation for the emergence of high-quality PhD training in these American graduate schools by 1900.

14 Later, Johns Hopkins was to incorporate an undergraduate level as well.

15 This 'Humboldtian revolution' included the reforms of the Prussian Minister of Education, Wilhelm von Humboldt, to the rather moribund German universities. The German 'revolution', with its focus on new knowledge production (modern research) by chair-professors in the emerging narrower, scientific-specialist fields of the 1800s (such as chemistry, physics, linguistics), is discussed further in Chapter 3.

16 At these American universities, departments generally had more than 10 senior faculty members – in contrast to the small 'institutes' (research units) at German universities, which comprised only a chair-professor and a few untenured academic assistants (see Chapter 3).

17 See Geiger (1986: 23, 32) for a listing of important journal publications and disciplinary associations.

18 By the 1990s they had been joined by nearly 200 other American 'research universities'.

19 In the section that follows I draw on Servos (1980), whose article was based on extensive work for his PhD thesis on physical chemistry in America from 1890 to 1933. Interestingly, the whole thrust of Servos's article is to highlight the change at MIT from the 1930s towards a more basic-science orientation – something that Etzkowitz (2002) blurs and largely ignores in his study. But see also Geiger (1986: 177–183) who, based on other sources, including especially the work of Servos, does not ignore this shift in the 1930s. I am indebted to Biddy Greene for pointing out the Servos article to me.
Until 1921, both basic and applied chemistry courses were offered through a single Department of Chemistry and Chemical Engineering, in which both Noyes and Walker were located (see Servos 1980: 537 – something not pointed out by Etzkowitz in his 2002 work), which thus heightened the tensions.

Noyes was in fact also involved in consultancy and donated some of his income from this work to his laboratory (Etzkowitz 2002). Thus, both the ‘purer’ scientist (Noyes) and the ‘applied’ scientist (Walker) were involved in consultancy work with industry alongside their academic research and teaching. As will be seen in the discussion to follow, this was true of most MIT professors throughout the twentieth century.

Etkowitz (2002: 38) notes that it was never clear if this should be interpreted as one day in five, or as three days in seven – highlighting Compton’s problem of containing time spent on consultancy work.

Geiger (1986: 182) notes that Compton also instituted a ‘tax’ on consultancy fees, which created a ‘professor’s fund’ that initially supported sabbatical leave for other academic staff.

For instance, the inaugural speech of President James Killian, who took over from Compton in 1949, clearly supported the idea of underpinning the work of this Institute of Technology with basic research, placing UIBR at its core (Killian 1949).

Further extensive arguments in support of my hypothesis about the effectiveness of larger and mission-orientated research groupings are given in Chapter 3.

A secondary reason would have been that Bush and his colleagues had become central players within the OSRD, and that most had an interest in supporting university-based research.

This refers to the December 1941 bombing after which America entered the war.

Etkowitz (2002: 5) describes how some manufacturing groups joined the academics within the Rad Lab to form subteams, while other contracts involved the scientists taking prototypes out to contracted companies.

In later chapters I term this collection of centres a large ‘research institute’.

Examples of this were the applied physics lab at Johns Hopkins that developed the proximity fuse (a shell to be detonated via a radio transmitter), and the lab for rockets and jet engines at Caltech.

In Chapter 3 I term this a small ‘traditional research unit’ based around a PI.

After the Second World War, health research funding in America emerged under the control of the new (and increasingly powerful) NIH.

After the Sputnik ‘crisis’ in 1957 (see Chapter 3), American defence agencies concentrated on funding more applied research – a shift away from their support for components of basic research in the previous decade. During the 1960s the more basic side of the research spectrum was supported primarily by federal government agencies and private foundations (Carnegie, Rockefeller, Ford, etc.) (Geiger 1993: Chapters 6, 7).

Geiger (1993: 24) suggests that, immediately after the Second World War, ‘ONR very quickly became the principal actor in the university research economy’, but that this only lasted a few years.
Etzkowitz (1994) also notes that, already by the 1950s, research centres comprised a third of the academic strength at MIT, and their role was explicitly recognised in university policy planning.

For example, Stanford entered into an agreement with General Electric along these lines, linked to company funding to build an extension of the Microwave Lab (Etzkowitz 2003: 115).

Colyvas (2007: 459) provides anonymity for the specific name and subfield of her ‘basic life science department’ in this Medical School, but it is clear from her analysis that the department focused on microbiology, including genetics, and linked its basic research to the biotechnology industry in the 1970s.

Jong (2008) shows a similar revolution occurring at the neighbouring Berkeley University, where more than 10 departments across the biological sciences within its College of Letters and Sciences became consolidated during the 1980s into two departments, including a new interdisciplinary ‘mega’ department of molecular and cell biology.
The spread of a second academic transformation in the last quarter of the twentieth century: A critical assessment

In 1992 an International Study Group (ISG) was established following a NATO-funded Advanced Research Workshop on academic-industry relations. ISGs are international groupings of specialists in particular issues of science and technology policy who work for a period of time with users in industry, government and academia on an agreed policy-led programme. Some current ISGs include work on defence technology under funding constraints and planned work on the international science and technology labour force. Future studies have been proposed on women in science, and on aspects of national innovation systems. (Healey 1994: 70–71)

The quotation highlights the link that existed in the 1990s between NATO thinking and a very wide range of academic studies in the sphere of science and technology, ranging from issues of defence to technology labour forces to women in science. Of note, too, is the fact that the work of a few of the authors cited in the previous chapter – including, for example, Etzkowitz (on U–I–G relations) – arose from ISGs in the early 1990s, or from thinking later in the 1990s that grew out of ideas generated by ISGs. Of course, the quote above is not meant to suggest that all this thinking about S&T policy had its roots in NATO! It is provided to highlight how seriously – in the early 1990s – a military organisation such as NATO took the questions of S&T and NSIs and associated U–I relationships, with various NATO-linked governments playing supportive roles in steering and funding policy research in these areas.

I would also suggest that from around the time of President Compton at MIT in the 1930s, there has been a growing perception of the value, for military technology, of use-oriented research emanating from universities – especially UIBR for purposes of military (and economic) superiority. Increasingly, too, the NATO-linked governments have realised that good UIBR needs a strong PBR foundation, built on academic excellence; the last thing the military needs is deficient missiles. So, as shown in the previous chapters, it should come as no surprise that top-quality academic publication is alive and well in ‘applied’ engineering departments of universities such as Chalmers in Sweden and MIT and Stanford in the USA.

However, there still remains an important puzzle to solve: if something new at universities has been evolving very slowly since even before the Second World War, why does there appear to have been a sudden, massive expansion of the third mission across universities from the 1980s? This has happened especially at research-
intensive universities, and not only in the USA. In Europe, where the transformation process gained momentum only a few years later, it has been strongly linked to the FPs of the EU, and since the 1990s this expansion has occurred across leading universities on other continents (as briefly discussed in Chapter 1). Substantial evidence thus suggests that the last quarter of the twentieth century witnessed a global second academic transformation, but the question remains: why has there been such a surge after the 1970s?

My argument in this chapter is that the systematic and relatively coherent form of this academic transformation – or revolution – needs theoretical appreciation. To achieve this, I would argue that we need to recognise the globally based economic slowdown of the early 1970s. We also need to understand the vital role that UIBR played during the 1980s and 1990s – particularly in the US economy but also in Europe – in enabling TNCs to ‘lift’ themselves, and the capitalist global economic structure as a whole, to a new, higher level of knowledge-intensive production (in which subfields such as biotechnology and ICT are simply the most obvious cutting edges). According to this argument, the spread of the second academic transformation is itself symbiotically linked to massive post-1970s global economic restructuring – a new ‘revolutionary’ phase of capitalism that emerged in the latter part of the twentieth century, for which the term ‘knowledge society’ is useful but, I believe, not theoretically sharp enough. A historical sociology of capitalist production, with ‘long waves’ of major technologies, is therefore presented as a starting point for the discussion of this position, with particular reference to the new post-1970s wave.

A third capitalist industrial revolution: The underpinning of the second academic transformation

For present purposes it is useful to view the history of capitalist production in terms of ‘very long waves’, making up first, second and third industrial revolutions, as detailed in Table 3.1 (also, in abridged form, in Table i.1). I have used the discussion by Dicken (2003: 88) of a series of 50-year economic growth cycles (1780–1830–1880–1930–1980), known to economists as Kondratiev long waves, but I have joined up each pair of 50-year cycles, making three nodes with ‘very long’ (100-year) waves, as shown in Table 3.1. I refer to each of these nodes or ‘moments’ as first, second and third capitalist industrial revolutions. These revolutions are each crucially shaped by what I term different ‘capitalist forms of economic organisation’, namely the small family firm, the national shareholding corporation and, finally, the TNC-cum-networks. I have found Dicken’s (2003: 87–89) technological descriptions for each Kondratiev cycle valuable, and have included the most important technologies listed by him for each period in the table.
Table 3.1 Conceptualisation of capitalist very long waves: Technological forces and socio-economic relations of production

<table>
<thead>
<tr>
<th>Capitalist industrial revolution</th>
<th>Major technologies ('technological regime')</th>
<th>Capitalist form of economic organisation</th>
<th>Associated academic transformation</th>
</tr>
</thead>
<tbody>
<tr>
<td>First (1770s–80s) (led by Britain)</td>
<td>Initially textile machinery, iron working, water power, pottery, etc. Later (from 1830s): steam engines, railways, etc.</td>
<td>Small family firm</td>
<td>First academic transformation (early 1800s until early 1900s)</td>
</tr>
<tr>
<td>Second (1870s–80s) (led by Germany)</td>
<td>Initially electricity, chemicals, steel, etc. Later (from 1920s): automobiles, aircraft, synthetic materials, etc.</td>
<td>National shareholding corporation</td>
<td>Second academic transformation (takes off from 1980s)</td>
</tr>
<tr>
<td>Third (1970s–80s) (led by USA)</td>
<td>Initially ICT, biotechnology, optical fibres, material science, nanotechnology, etc. Later: ?</td>
<td>(Truly?) TNC-cum-networks</td>
<td></td>
</tr>
</tbody>
</table>

During the first industrial revolution (encompassing a specific technological regime-cum-form of economic organisation), all the major technologies (textiles, water power, later railways, etc.) were based on inventions by practical men (it was men who played such roles during this period). There was knowledge embedded in such inventions (for instance, a textile spinning machine or a steam engine), but it was not the kind of knowledge generated within the universities of the time. Then, during the second industrial revolution, beginning in Germany in the 1880s and spreading to the USA and elsewhere, science certainly did play a role.

Three points need to be made about this post-1870s second industrial revolution in order to contrast it with what is proposed as the third industrial revolution after the 1970s. Firstly, even where university knowledge did play a part from the 1880s onwards (for instance, in electrical and chemical technologies), this was knowledge based primarily on laboratory observation and experimentation – on laws derived from empirical observation (for example, electrical resistance in relation to volts and amps), usually without an advanced theoretical understanding of the underlying processes. One might say that PAR was dominating the whole discovery process, which was linked to these new technologies (making up the ‘technological regime’ of the second industrial revolution) after the 1870s.

Secondly, while such a form of laboratory science did help to bring about the second industrial revolution, it was very seldom a main factor in this process. Many other technical, economic, social and political forces were major factors, linked closely to new national capitalist corporations – such as Ford, Shell and Volkswagen – that rose to dominance in the half-century after the 1870s. Factors such as the ready availability of raw materials from colonies (through politico-economic imperialism), new forms of semi-skilled production based on organisational innovation (such as the Fordism
of mass assembly lines), the role of the stock exchange (providing finance for the new national corporate capitalism that was superseding the family firm; see Table 3.1), and even military interventions to secure economic dominance (for example, the USA in Latin America), were generally more important than scientific knowledge as driving factors of this long-wave, second capitalist industrial revolution.

Thirdly, as can be observed in Table 3.1, the first academic transformation (beginning in Germany in the early 1800s) did not coincide with the second industrial revolution; as shown in Table 3.1, it ‘straddles’ the first and second industrial revolutions. A corollary of this is that universities (and their research activities) were not a central factor in the second industrial revolution.

During what I conceptualise as the third capitalist industrial revolution after the 1970s, scientific knowledge, led by scientific theory, became a crucial factor in facilitating the economic transformations that took place. Such theory was rooted in basic physics, chemistry and biology, and often included mathematics and computational methods. The major technologies listed in Table 3.1 for the third long wave show this clearly: one cannot think of ICT, or the LEDs (light emitting diodes) used for optical fibres, or nanotechnology, without reference to the underlying theories based on modern physics, nor can one imagine biotechnology without genetic theory. Scientific theories, I argue, primarily generated by UIBR within research-intensive universities as part of the second academic transformation, have been fundamental to this third capitalist industrial revolution. This symbiotic relationship is the focus of discussion in the next subsections of the chapter.

The direct link between the post-1970s third capitalist industrial revolution and UIBR

As argued in Chapter 2, one can consider the beginnings of these new technologies (microwaves, atomic fission, etc., developed at MIT, Stanford and elsewhere well before the 1970s) as associated with an embryonic second academic transformation. The third industrial revolution has seen not only the emergence of new major technologies but also, with regard to the ‘capitalist form of economic organisation’ (Table 3.1), the emergence of TNCs and their networks and associations with smaller firms, either as subsidiaries or involving complex subcontracting relationships.

The points just made about the second academic transformation and third industrial revolution lead to a related question: why did such a global economic revolution emerge after the 1970s, so that, at the superstructural level of universities, the third mission becomes not a sporadic occurrence at certain key institutions, but rather a systematic movement – for which the concept of a second academic transformation might be appropriate?

From my perspective, at the socio-economic level, the viewpoint of the International Labour Research and Information Group (ILRIG) is a useful summary of the underlying global industrial restructuring, which I view as giving rise to an
international academic transformation: ‘…globalisation is a process of restructuring the world economy. This restructuring process is a response to the crisis in the capitalist economic system which began in the early 1970s. The main purpose of this restructuring is to find new ways for business to maximize profits’ (ILRIG 1998: 7).

The ILRIG approach to the oft-used term 'globalisation' thus takes as its starting point the capitalist economic slowdown of the early 1970s – an economic crisis – which resulted in a restructuring process to enable companies to find new modes of profitability. One vital way of restructuring after the 1970s was a change in ‘economic form of organisation’ from nationally based corporations to global or transnational forms of corporate organisation. The valuable ILRIG viewpoint on globalisation, embodying the idea of a 1970s capitalist slowdown and subsequent restructuring, thus differs from more typical and superficial approaches which see globalisation after the 1970s as being based primarily on the expansion of socio-geographical linkages across the globe, as for example in the Trade Union Research Project definition: ‘The process whereby the economic, political, social and cultural links between different countries, industries, companies, organisations and individuals of the world are increasing, is referred to as globalization’ (TURP 1997: 21).

The notion of a massive capitalist restructuring process (what I term a third capitalist industrial revolution) taking place after the 1970s not only helps to focus attention on the emergent TNC system of firms (as a core economic form of organisation); it also points to an equally massive and parallel transformation of major technologies in order to increase profitability. I suggest, moreover, that one fundamental source used by TNCs for raising profits was the development of new products, in which university basic research was deeply embedded. New major technologies, as already noted, were being developed mainly in the new research fields of ICT, biotechnology, computer science and new materials. For example, the personal computer (which emerged in the 1980s) would have been unthinkable without the microchip, which incorporated basic physics (electronics) and advanced chemistry (new materials); and new bioproducts emerged from bioinformatic technology, which was rooted in genetics. Furthermore, it will be proposed in Part 3 that the twenty-first century will see an increasing spread of new technologies derived from a much wider range of academic disciplines and fields, including the social sciences. This might include, for example, social theories based on new modes of planning cities and their transport and housing, or innovations in work organisation, or the development of new cultural forms.

Clearly, many factors have facilitated this post-1970s restructuring of TNC profitability. For example, at the ideological level there has been the neoliberalism of Reagan and Thatcher, driven forward by the World Bank and others into the early twenty-first century. At the political level there have been, inter alia, the fall of the Berlin Wall and the enlargement of the EU. But the argument here is that the sourcing of scientific knowledge for company profits, rooted particularly in UIBR embedded in research-intensive universities, has been particularly fundamental for economic lift-off since the 1980s.
For this reason, as already noted, the second academic transformation (with its third mission of development) has been shown (Table 3.1) as symbiotically linked to the third capitalist industrial revolution. In contrast, the first academic transformation (with its second mission of basic research becoming joined with the first mission of teaching) has been shown in the same table as sitting uneasily between the first and second industrial revolutions, that is, as not fundamental to either of these two earlier industrial revolutions.

Linked to this, one can thus observe an increasingly systematic process of research-intensive universities embracing, internationally, a third mission of socio-economic-cultural development of society alongside the first and second academic missions, which had usually dominated their practices up to the 1970s. The importance of UIBR for this third mission and the vital role of government in facilitating the U–I research dynamic are explored further in the next section.

The third mission: PBR alongside UIBR, supported by government funding

In examining the third capitalist industrial revolution, it is important to acknowledge the centrality of PBR as its base. On this foundation stand the current second academic transformation and its associated third mission, encompassing UIBR and also PAR. At this point it is therefore useful to explore my hypothesis that American university science – based directly on UIBR and therefore indirectly on PBR, and all funded substantially by the American federal government and its agencies – has been a crucial factor in the US-led third capitalist revolution that began in the 1980s. During the last quarter of the twentieth century this provided American industry with a cutting edge in technological innovation when competing with European and Japanese companies.

Serious consideration therefore needs to be given to the claim by Crow and Tucker (2001) that the post-1945 American research university system has been America’s hidden technology policy. Moreover, the issue of government financing of research needs to be considered, since a core characteristic of this university research system has been federal government agency funding for basic research during the more than five decades since the Second World War. In South Africa, as will be argued in Parts 2 and 3, government research funding is significantly weaker than in the USA and the EU, not only for PAR, but especially for PBR and UIBR – with potentially dire consequences for the third mission of our universities.

Crow and Tucker assert that the federal funding of basic and other forms of research at American universities for many decades after 1945 made available, in multiple ways, a technological base that enabled the American economy to develop and expand – or, in my terms, to ‘lift off’ dramatically – during the new long wave from the 1980s. As they put it:

The American research university system, as it has evolved through policies and actions in the last 50 to 60 years [following Vannevar Bush’s 1945 report, Science, the Endless Frontier], constitutes a de facto technology
policy...Universities have been important vehicles by which all federal agencies have realized their missions through R&D support. Beyond supporting specific agency missions, these technology policies have had the cumulative effect of building a technology profile for the United States that has gone largely unrecognized, or at least unappreciated. (Crow & Tucker 2001: 2)

As mentioned in Chapter 2, these two authors argue, moreover, that whereas Bush and other scientific leaders who followed in the decades after 1945 sought to establish basic research funding as a federal government priority, what actually happened was that such funding contributed within American research universities to the massive growth of a wide range of research capabilities. These included not only basic research, but also what they term ‘use-oriented basic research’ as well as ‘fundamental’ and ‘not so fundamental technology development’ (Crow & Tucker 2001: 6).

To justify their contention that a very ‘wide range of research capabilities’ was constructed at these universities after the Second World War (spanning essentially what I have designated as PBR, UIBR and PAR), Crow and Tucker point out that the extensive federal funding for research helped to create what they term ‘disciplinary diversification’ in research – though this has often gone unnoticed. For example, they note that, while Bush’s linear model usually focused on the science departments of biology, chemistry and physics, in fact in the decades after the war it was often areas such as agriculture, health and computer science that received large amounts of funding.

And this was not simply ‘applied research’ funding. Crow and Tucker point out that agricultural research funding was linked to diverse sub-disciplines such as entomology, soil sciences, plant molecular biology and microbial ecology, which were themselves linked to chemistry and biology. I suggest, with reference to Stokes’s categories, that this laid the basis for a complex intermix of PBR–UIBR–PAR across such fields. Similarly, the funding of health sciences at universities drove disciplinary diversification, with the biosciences and clinical and medical departments all intermeshed in a research network across the pure–applied spectrum. Computer science research, too, has been both ‘basic’ and ‘applied’ and has ‘mingled freely’ with a range of other disciplinary subfields ranging from mathematics and physics to computer languages as well as signal processing and data storage (Crow & Tucker 2001: 6).

This post-Second World War federal research funding regime eventually spread widely across American higher educational institutions in diverse ways, which these two authors argue enabled numerous previously ‘non-research’ universities to raise their research profiles significantly in a relatively short time (e.g. UC-San Diego, Washington, Duke and Rensselaer Polytechnic). This disciplinary diversification:

...was part and parcel of the rapid growth of American research universities in the post-Second World War era, only to be enhanced after the launch of Sputnik. Throughout this expansion, these universities have served as
enabling environments for researchers to span fundamental and applied work freely, if they so wished. (Crow & Tucker 2001: 6)

Thus, during the decades after 1945, federal government funding of the American university system – with a focus on basic research and its diverse disciplines – laid, I would argue, an essential foundation for the capitalist industrial technology lift-off after the 1970s.

If the perspective of Crow and Tucker (2001) is inserted alongside my perspective of a third industrial revolution, it may be argued that during the global economic slowdown in the 1970s it was this unintended hidden ‘technology policy’ that proved to be a fundamental resource for USA-based TNCs. In the international economic slowdown of the 1970s, these companies could turn to their advanced university research system for technological innovation. For the capitalist new very long wave that began in the 1980s and 1990s, TNC restructuring ‘to find new ways for business to maximise profits’ (ILRIG’s perspective) therefore linked symbiotically with the rapid spread of a second academic transformation and third mission at American universities.

Geiger’s work on the funding patterns of American university research during the period from 1945 until the late 1980s yields very interesting support for the above hypotheses. In particular, his observations of a significant increase in U–I research funding linkages from the end of the 1970s fit closely with my proposition that a third capitalist industrial revolution began at this time.

Of the post-1957 Sputnik decades, Geiger writes that the 1960s saw a big increase in federal government funding, especially for basic research:

[American] university R&D, which had been rising at a healthy rate in the mid-fifties experienced near 20 percent increases almost every year from 1959 to 1966. In the decade 1958–68 university R&D rose 371 percent; almost 80 percent of the increase was supplied by federal funds; and more than 80 percent of these new federal funds were directed to basic research. (1990: 13)

Geiger further shows that a crucial levelling off of this trend occurred from about 1966 to 1968. At this point, too, industry sponsorship for university research was at its lowest at around 1.4 per cent (Geiger 1990: 14). Then, according to Geiger, things changed. During the 1970s the proportion of industry funding of university research remained low, but federal funds became progressively tighter, so that university R&D funding decreased steadily as a percentage of GNP for a decade after 1968. However, after 1978, he argues, university R&D funding rose again as a percentage of GNP, and by 1987 had surpassed the peak 1968 level (Geiger 1990: 15, Figure 3). Crucial here was the fact that the sources of university research funding were changing in the 1980s, as industry funding was beginning to climb:

[By 1987] the relative federal contribution to university research funds (percent of total) has fallen back to where it was at the beginning of the 1960s. Meanwhile, the fastest growing component of the university
research economy [in the 1980s] has been industry-sponsored research, which is clearly programmatic in character [i.e. having an identifiable utility for the sponsors]. (Geiger 1990: 15)

Thus, after a boom in federal government funding of university research in the post-Sputnik era of the 1960s, followed by the stagnant decade of 1968–78, the 1980s saw a rise in university R&D funding, mainly because industry funding had risen to close to 10 per cent of total university R&D. American U–I research funding linkages had thus increased by the end of the 1980s, and in particular ‘applied R&D had expanded to 33 percent of total academic R&D’ (Geiger 1990: 15). However, Geiger qualifies his description of this ‘application-oriented’ trend with an even more significant observation: ‘But the more important trend is that an increasing proportion of basic university research has consisted of programmatic research for interested sponsors. About two-thirds of current industry-sponsored [university] research is classified as basic – the same as [for] total university research’ (1990: 15; my emphasis).

Whatever questions one might raise about the complexities of the ‘basic–applied’ classification system used here, this does seem to suggest strong support for the arguments in the previous section: that from the 1980s onward in the USA, U–I research linkages were increasing significantly, and industry was often most interested in sponsoring support for basic research of a ‘programmatic type’ (i.e. within a mutually agreed programme) – or, in terms of Stokes’s typology, for UIBR.

The data provided by Mowery et al. (2004: 24, Table 2.1), writing two decades later, show that industry support for academic R&D has continued to rise. And they argue:

By 1980 industrial support for university research (excluding university-based FFRDCs [Federally Funded Research and Development Centres], had rebounded [from the 2.7 per cent they cite for 1970] to account for more than 4 per cent of academic research spending, and this share increased further to approximately 7.4 per cent by 1998. (2004: 26)

However, against this rise in U–I research linkages since the 1980s one needs to bear in mind that the figure for American federal government support of university R&D is still nearly 60 per cent (compared to industry’s approximately 10 per cent). Mowery et al., for example, show a levelling off of federal support for academic R&D in the 1990s to 58 per cent of total academic research funds by 2000. And for the year 2000 their data on American academic research funded by federal agencies showed almost 80 per cent in total derived from the NIH (61 per cent), the Department of Defense (9 per cent), the Department of Energy (4 per cent) and the space administration NASA (4 per cent) – this as compared to the NSF with only 15 per cent (Mowery et al. 2004: 25, Table 2.2). These figures highlight Geiger’s point that much basic research has actually been ‘basic-applied combined’ (i.e. UIBR), ‘programmatically’ linked to work on health, space, defence, energy issues and so on.

An essential point emerging from the data of Geiger and others is that there is still massive federal government (and local state government) subsidisation of university
research, despite the linkage of the second academic transformation – especially at American research-intensive universities since the 1980s – to a relative increase in U–I research funding relations. This federal government support – at just below 60 per cent of university research funding in 2000 – is not only for UIBR and PAR but, as importantly, for PBR, which underpins both UIBR and PAR.

If one looks at individual research universities in the USA the point is made even more strongly. At MIT, the leading recipient of industrial funding, ‘industry-sponsored research’ comprised only just over 15.25 per cent of total research funds for the fiscal year 1994/95, and for the more ‘pure research-oriented’ Johns Hopkins the figure was 1.33 per cent (Feldman & Desrochers 2004: 123). Even if one turns to the EU, OECD data for 1999 show that industry funding for higher education R&D was less than 10 per cent for almost all European countries (Germany being the biggest recipient with 13 per cent), with government in its various forms again being by far the dominant funder (Dosi et al. 2006: 1460, Table 10).

It is thus not surprising, as noted in Chapter 1, that writers such as Pavitt (2000) and Dosi et al. (2006) in Europe have rejected the so-called ‘European Paradox’ which asserts that, compared to the USA, Europe is strong in basic science but weak in technological innovation. They argue that the EU should not only fund the FPs – with their relative ‘applied science’ stress – but should also refocus on basic research in order for Europe to catch up with the USA. As also noted in Chapter 2, this has led since 2005 to enhanced ‘frontier research’ (in essence a combination of PBR and UIBR) through the establishment of a Scientific Council of 22 leading academics of the new European Research Council. It was noted further that, in countries such as China, Japan and elsewhere, a massive thrust has taken place since the 1990s to increase research-university capacity – including the sphere of PBR.

Three major points have emerged from the discussion in this section. Firstly, as argued by Crow and Tucker (2001), American government funding of university research after the Second World War did provide – and in fact has continued to provide – an essential yet hidden technology policy for industry, particularly in relation to support for university-based PBR and UIBR. But, secondly, it is important to note that the proportion of federal government funding for American university research declined from an all-time high in the late 1960s (just under 80 per cent of all university research) to a somewhat lower proportion by 2000 (just under 60 per cent). And, thirdly, after the 1970s this relative gap was filled by American industry funding for university research, linked to a new industrial revolution based on a more knowledge-based economy. The international U–I research dyad has clearly become significantly stronger since the 1980s. It is thus vital not to lose sight of the core U–I element associated with the second academic transformation, while still recognising the crucial and continuing role of government funding in underpinning this process.
Some writings on the ‘knowledge economy’: Conceptual strengths and weaknesses

To conclude this exploration of the new global capitalist industrial revolution that has been taking place since the 1980s, it is useful to mention very briefly a few other concepts concerning the ‘knowledge economy’ – an umbrella term that captures the core of what a range of writers are examining in their works. The discussion here touches on only a few writers – Leydesdorff, Castells, and Gibbons et al. – whose works have been very influential (especially in South Africa) and whose concepts are indeed valuable. However, what is missing in all their analyses is a clear link to the idea of a third capitalist industrial revolution after the 1970s, which I have suggested is itself associated with university-based UIBR for many of its core technologies. These writers add value by examining the issues discussed above from different angles – but their additions need to be framed by the broader idea of a third capitalist ‘long wave’ if the concepts they introduce are to achieve a strong impact.

Leydesdorff has been closely associated with Etzkowitz in his writings on the triple helix. In a recent book, *The Knowledge-Based Economy*, he notes that this important view of the economy was introduced in the 1990s by ‘evolutionary economists’ (for example, Pavitt, Lundvall and Dosi et al.), linked to the idea of an NSI (Leydesdorff 2006: 15). I view both these concepts as valuable, and Leydesdorff points out that the 2000 EU Lisbon Strategy (whose goal was to make the EU the most competitive economy in the world by 2010) freely used the idea of the knowledge-based economy in its discourse. As can be inferred from discussions in the previous chapters, I have accepted, albeit critically, some of the insights conveyed by the idea of the triple helix, and in this book on the knowledge-based economy, Leydesdorff (2006: 15) elaborates on how the I-G dyad involves ‘co-ordinating mechanisms’ between ‘economic exchange’ (industry in a capitalist market) and ‘political control’ (government steering). He argues that if one introduces a third mechanism via universities, involving the ‘systematic organization of knowledge production and control’ (Leydesdorff 2006: 15), this very significantly changes the dynamic of the research system, with now a triad of mechanisms affecting the knowledge-based economy.

Leydesdorff’s approach, with the triple helix viewed in this way, is a valuable contribution (even if there is an absence of the fourth, civil society helix described in Chapter 1 and discussed further below). Moreover, his book elaborates on the fact that knowledge (in a knowledge-based economy) not only codifies the meaning of information, but seeks, through scientific knowledge, ‘to open the discourse about future events’ (Leydesdorff 2006: 17) – because science strives to anticipate future patterns. Moreover, not only do scientifically informed policy initiatives seek to ‘construct the future’ but, by studying possible feedback effects of policy on constructions being attempted, anticipatory feedback dynamics are added. ‘In other words, science-based representations of possible futures (such as “competitive advantages”) feed back on historically manifest processes’ (Leydesdorff 2006: 17).
There is clearly a set of rich ideas here. Yet it seems to me that there is no underlying conceptualisation or periodisation of a third capitalist industrial revolution – with its associated major technologies linked to a second academic transformation, as I have previously elaborated. Surely, therefore, some of the force of Leydesdorff’s insights is lost?

A similar argument can be made about the insights of Castells, who has worked intensively with the idea of knowledge and information in relation to the ‘new economy’:

*We are indeed in a new economy. This new economy is not only the California [e.g. Silicon Valley] economy but it has extended worldwide with different manifestations. It is of course a capitalist economy…Labour is still the basis of any economy – and this is particularly so of the new economy. It is the source of value creation…The new economy…is an economy in which productivity and competitiveness are based on knowledge and information.* (Castells 2001a: 2)

Castells’ comments resonate closely with much of the discussion in this chapter, even though he does not talk explicitly about a third capitalist industrial revolution and associated TNCs. In another article in the same book, he argues that high-quality research at universities is vital for countries of the so-called Third World: ‘The new Third World universities must also emphasise research, both basic and applied, since this will become the necessary ground for the upgrading of the country’s productive system. Research must be connected both to the world’s scientific networks and to the specific needs and productive structure of the country’ (Castells 2001b: 218).

Castells’ last point about networks is associated with his broader concept of international knowledge ‘networks’ and ‘nodes’. Implied here is the notion that even parts of the Western Cape (such as the central business district and the universities) can become nodes within these global knowledge networks, connecting with the knowledge and information of the so-called First World. But there is also, he gloomily predicts, an ever-increasing ‘fourth world’ of other types of nodes (for instance, squatter districts without any electricity), which are disconnected entirely from the knowledge/information networks of the First World. Hence, for Castells, it is knowledge connectivity, not geographical place, that defines one’s first/fourth world ‘position’.

Valuable too is Castells’ idea of ‘self-programmable labour’: a form of labour that has ‘the built-in capacity to generate value through innovation and information, and…to reconstruct itself throughout the occupational career on the basis of this education and this information’ (2001a: 13). This idea implicitly highlights how important it is for research workers – self-programmable labourers – to receive advanced training, preferably up to PhD level, as will be discussed in Part 2 of this book, where numerous case studies illustrate the underproduction of such research workers in South Africa. In addition, I suggest that the labour of what could be called
'use-inspired basic scientists' may well be the labour type within this category of self-programmable labour that is most prized of all.

Also important is Castells’ argument that it is essential for research centres and units at our universities to maintain linkages with international research centres:

Science and technology are globally integrated in the sense that all major research centres have connections to developing countries. At the same time it’s highly asymmetrical...we have an extraordinary concentration of science and technology, particularly information technology, research and development, in the leading economies...[but] while they are concentrated in terms of research centres, their networks are interactive and therefore you have the ability to diffuse technological capacity to a number of developing countries, while at the same time being connected to the centres of information processing. (2001a: 9)

As I shall elaborate in Part 3 of this book, such ‘connectivity’ of Western Cape research centres with other international centres enables them to sustain their ability to undertake high-quality UIBR and PAR, and be part of the global second academic transformation. However, despite all the valuable insights of Castells, what seems to be missing is a clear focus on the break after the 1970s which heralded a third capitalist industrial revolution and was driven by TNCs, and associated with the new technological regime and its vital links to UIBR.

The book by Gibbons et al. (1994) which elaborates on their ideas of ‘Mode 1’ and ‘Mode 2’ knowledge production (discussed below) had an exceptional influence on thinking about science policy and research enhancement in South Africa after the late 1990s (see, for example, Kraak 2000; Muller 2000; Ravjee 2002). But it imparts little clarity about a global capitalist production economy – or even a third capitalist industrial revolution – which could have created a scaffolding for their otherwise valuable insights.

Gibbons et al. (1994) do point to important transformations taking place in knowledge production, especially in current research practices. For example, they argue that for over a century Mode 1 knowledge production has embodied a ‘classical’ historical mode of research, which is curiosity-oriented and discipline-based. This has been led by relatively autonomous university professors, but a new type or mode of knowledge production has also been emerging, with different characteristics. The authors contend that these characteristics can be seen as a new type, which they refer to as Mode 2. Nowotny et al. make the following points in this regard:21

- Mode 2 knowledge production is ‘generated in the context of application’ – ‘the total environment in which scientific problems arise’;
- it is ‘trans-disciplinary’ – ‘unlike inter- or multi-disciplinarity, it is not necessarily derived from pre-existing disciplines’;
- ‘there is much greater diversity of sites at which knowledge is produced’ – not just within universities;
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- it is 'highly reflexive' – in terms of a 'dialogue process', it is a 'conversation between research actors and research subjects', and embodies greater 'accountability'; and
- 'novel forms of quality control' are emerging – traditional university-based peer reviewers and their criteria are becoming more broadly constructed (Nowotny et al. 2003: 186–187).

In their book of 2001, a new idea like 'agora' – 'the problem-generating and problem-solving environment in which the contextualization of knowledge takes place' (cited in Nowotny et al. 2003: 192) – offers additional insights with which, I would suggest, one can interrogate Stokes's concept of UIBR.

However, it can be argued that the idea of agora still misses the kernel of Stokes's idea – of use-inspiration being connected to (much) basic research. Furthermore, the Mode 1/Mode 2 dichotomy of Gibbons, Nowotny and their colleagues to some extent reinforces a simplistic division between pure and applied research, which Stokes sought to avoid by the addition of his Pasteur's Quadrant. I thus view Stokes's idea of UIBR as the embedding of basic research within 'use-orientation' as a theoretical advance that is largely absent within the Mode 1/Mode 2 framework.

Moreover, although Nowotny et al. (2003) do list the 'commercialisation of research' as a vital factor shaping what they view as the 'changing research environment' of the past few decades, the concept of a new (third) phase or long wave of capitalism – including TNCs and new major technologies – seems absent from their theoretical framework. In fact, neither a sharp economic break (revolution) after the 1970s, nor capitalism itself, appears to be central to their analysis.

Theorists such as Gibbons and Nowotny, as well as Castells and Leydesdorff, certainly add significant value to the concept of a knowledge economy, with a range of important insights. However, like the vast majority of theorists of new research modes in countries of the global North, they do not locate any of their ideas within a general perspective of a third capitalist industrial revolution, itself linked to a second academic transformation incorporating U–I–G research relations. The idea of a fourth helix of U–CS direct research linkages being added to the triple helix of U–I–G relations is, moreover, almost totally absent from their work. The next section of the chapter will focus on the nature and significance of this U–CS helix.

The importance of a fourth helix

I highlighted in the Introduction to Part 1 how I had found, as my studies of the 11 Western Cape research groups unfolded, that the triple helix of U–I–G research relationships dominated what I have termed the 'fourth helix', involving U–CS relationships. The latter I defined provisionally as groupings external to the university, such as community and labour organisations and social movements, other civic structures such as women's or health organisations, and NGOs and local and regional administrative bodies (as opposed to national government bodies). I proposed in the Introduction that my investigation needed to explore this
dominance of U–I relations – with government often acting as coordinator of the research processes – in terms of how, empirically, this was the prevailing situation at the Western Cape universities. I also suggested that one needed to examine how the idea of the triple helix and its associated concept of NSIs (driven by U–I linkages) – that were dominant in ‘northern’ academic discourses – itself tended to reinforce how this ‘should be’, thus serving to reinforce the orphan status of U–CS relations still further (see Figure i.1).

In Part 2 the empirical situation at the various Western Cape universities will be assessed. To set the context of this investigation I shall now explore how the prevailing hegemony of northern academic discourses has served to push onto the periphery the idea of U–CS research relations. This is despite certain attempts in Europe and especially the USA in recent decades, often outside the mainstream of research-intensive universities, to include community engagement more firmly within the third mission of universities. In Part 2, I argue further that for South Africa, but also internationally, the treatment of the fourth helix as an ‘orphan’ impacts extremely negatively on a university’s ability to contribute towards the socio-economic–cultural development of a knowledge society.

A missing idea in northern academic discourses: U–CS research relationships

Debates about the triple helix in leading international science and technology journals (including those with a focus on university research) appear to contain very few analyses of U–CS research relationships – a lack that is striking for many readers from the Third World. This lack seems especially strange in South Africa. In this country – particularly during the anti-apartheid struggle years of the 1970s and 1980s, and also later in the policy engagement years of democratic transition in the 1990s – numerous university research groups and individual academics became involved in substantial civic engagement research relationships. These were mainly with groups in trade union and civic organisations, local government bodies, and even political organisations. Perhaps the best insight into these activities can be gleaned from issues of the South African Labour Bulletin from the 1970s until the present. The Labour Bulletin was itself an initiative of (mainly) university academics working with the emerging trade union movement, its first issue appearing in April 1974 (see SALB 2004).23 Thus university-based scholars undertook various forms of research and other scholarly support services (the teaching of off-campus courses, advocacy research linked to struggles on the ground, advice on policy documents, workshops on environmental issues, and so on) for a range of formal organisations such as labour, women’s and community groups, and also for informal groupings.

However, an examination of articles about university-based research over the past two decades in leading international journals, such as Research Policy or Science and Public Policy, reveals hardly any references to serious scholarly research by academics engaged with or in the interests of labour or community organisations – in contrast to the mass of articles in virtually every issue on research associated with industry or
government. Moreover, many articles referring to the triple helix reflect an economic ‘innovation anxiety’, which seems so dominant in the USA and Europe, with a resultant focus almost exclusively on how industry can become more innovative and how universities and government might facilitate this.\textsuperscript{24} It seems that the majority of northern academics writing for such journals and innovation discussion fora have become enmeshed in the new third capitalist industrial revolution, with industry as the focus of almost all their attention.

This tendency can be usefully illustrated with reference to the work of Etzkowitz and his colleagues, specifically to their concept of the triple helix. When the issue of a possible fourth helix began to arise in the years after 2000 (for example, in Leydesdorff & Etzkowitz 2003), the discussion seemed to move off in a direction different from that of civil society viewed as ‘social structure’ (comprising labour and other civic organisations and groups) – as I have defined it in relation, for example, to the \textit{engaged} scholarly research work of progressive South African university groupings. Instead, what appeared as the focus was the idea of an \textit{external public} ensuring the social accountability of the ‘real’ research work taking place inside the U–I–G triple helix.

This pattern of diverting questions into paths of special concern to northern debates can be seen clearly in relation to the fourth helix question that surfaced in some debates at the Triple Helix Conference of 2002 in Copenhagen. After this Fourth Conference in 2002,\textsuperscript{25} Leydesdorff and Etzkowitz (2003) wrote their article with a response, entitled ‘Can “the public” be considered as a fourth helix?’ They did not, however, confront the issue of ‘the public’ in the analytical terms suggested earlier, namely of civil society as a social structure, comprising not only elite U–I–G groupings but also popular organisations, social movements and groups of poorer and marginalised strata and classes in society – all engaged in research projects with university-based researchers on an ongoing basis. Their article asks only how the science of innovation of the U–I–G triple helix can be made more publicly accountable (Leydesdorff & Etzkowitz 2003: 57), posing the question in terms of existing northern debates about the ‘democratisation of S&T policy making’.\textsuperscript{26} Not surprisingly, the issue is thus deflected into questions of ‘ethical, legal and social impact studies’, with the ‘public’ being central to an external ‘public discussion about innovation policies’ (Leydesdorff & Etzkowitz 2003: 58), which they perceive as needing to take place alongside the triple helix of U–I–G.

At the Fifth Triple Helix Conference in 2005, the fourth helix issue was more explicitly acknowledged when the idea of such a concept having some sociological substance began to be hinted at: ‘Various categories have been suggested [with reference to a fourth helix, by a few delegates to the 2005 conference] including labor, venture capital, civil society and the informal sector’ (noted later in Etzkowitz & Zhou 2006: 79). Yet, a year after this conference, Etzkowitz and Zhou (2006) took the issue explicitly in the direction of ‘public accountability’ again. They maintained that the triple helix is the fulcrum around which the real research innovation process
unfolds: ‘Adding a fourth helix might cause the triadic model…to lose its creative

Etzkowitz and Zhou nevertheless appeared to feel that there was still a missing
dimension of ‘sustainability’ in the triple helix model. They viewed this as a
mechanism for ensuring that the ‘innovation’ produced by the U–I–G triad did not
produce negative or harmful effects. They proposed yet another helix of university-
public-government relations, the yin, to ensure that the yang (U–I–G) of innovation
did not get out of hand: ‘To resolve this paradox, we propose an alternative
university–public–government (yin) Triple Helix as a complement to the university–
industry–government (yang) Triple Helix’ (Etzkowitz & Zhou 2006: 79). Or, as they
succinctly put it later in their article:

The two helices operate in tandem. The university–industry–government
Triple Helix works to promote innovation and economic growth, while
the university–government–public one serves as a balance wheel to ensure
that innovation and growth take place in ways that will not be harmful to
the environment and health…Thus, it may sometimes seem that there is a
fourth helix but the model actually consists of a Triple Helix of interacting
twins, working together as a dynamic yin/yang pair that advances sustainable
economic and social development. (Etzkowitz & Zhou 2006: 80)

In this way, therefore, as in most northern articles on the issue of U–CS research
relations, the question is either ignored entirely, or given subordinate or orphan
status, or (as in this example of Etzkowitz and Zhou) deflected into different issues
of concern and debate within mainly northern academic circles. There thus seems to
be a limited conceptual framework within which to capture U–CS research linkages
as a genuine fourth element comprising strong and engaged research-based relations
between university researchers and civil society groups or organisations.

To be fair, some qualifications to the above need to be made. There are some
currents – albeit relatively small ones – in northern university academic work and
debate that focus on U–CS research linkages in terms of what I have characterised
above as genuine ‘civic-engaged scholarship’ with labour and community groups
and organisations. For example, since the 1970s in Europe there has been a ‘science
shop’ movement, initiated by academics and students associated with the student
movement of the early 1970s. As Farkas’s study points out, this began with the
University of Amsterdam’s science shop (wetenschapswinkel) seeking to ‘assist in
solutions’ of problems posed by non-university clients:

So began the first Dutch science shop, as volunteer initiatives by students
from the Dutch student movement of the late 1960s and early 1970s. These
students and university employees sought at once to change the character
of university research and to support activist groups working on issues
pertaining to environment, feminism, nuclear resistance, minorities and
the workplace. (Farkas 1999: 33)
Such science shops have continued up to the present, with attempts in the last few years to strengthen the movement (Living Knowledge 2010). However, it has always involved mainly students, with relatively few academics and other university personnel drawn in. Interestingly, Leydesdorff, for example, was himself involved in 1977 with the institutionalisation of the first science shop at the University of Amsterdam, and a few years ago was contracted through an EU-funded research project to examine the evolution of a sample of science shops in Europe (Leydesdorff & Ward 2005). His findings suggest that in the recent period much of the work has been linked to student dissertations – sometimes of undergraduates but frequently at master’s level – with academics seldom playing a major independent research role (Leydesdorff & Ward 2005: 362; see also Farkas 1999: 37). Another finding was that most of the projects functioned as consultancies ‘with a low threshold for economically weak but politically urgent demands’ (Leydesdorff & Ward 2005: 363) – in other words, with issues driven more by politics than practical economic solutions. Moreover, research reports of the science shops were seldom considered as ‘results that [could] be submitted to scientific journals’ (Leydesdorff & Ward 2005: 368), that is, they were viewed as probably not based on strong scholarship or powerful UIBR. Importantly, by the 1990s, the activities of such science shops were marginal to the core business of their universities (Leydesdorff & Ward 2005: 369; see also Farkas 1999: 36).

In essence, therefore, the European science shop movement, after ambitious beginnings, has always remained very marginal to the real research business of research-intensive universities in Europe, with its ‘engaged scholarship’ being rooted mostly in student dissertations rather than in the cutting-edge research projects of academic staff themselves.

Admittedly, in the USA in the past two decades there has been a committed movement among a section of American academics to assert the importance of what has now become known as ‘engaged scholarship’ together with the community.27 This followed the publication of the work of Boyer (1990), which sought to expand the idea of curiosity-oriented research (essentially what he called the ‘scholarship of discovery’) with his inclusion of the scholarship of teaching, of integration and of application – and also the ‘scholarship of engagement’ (Boyer 1996). The 1996 article was published in the first edition of the Journal of Public Service and Outreach,28 which has been carrying high-level debate and academic studies about what it terms ‘community engaged scholarship’ for well over a decade. Important, too, have been a spate of influential American reports – for example, the Kellogg Commission (1999) and American Association of State Colleges and Universities (AASCU 2002) – following Boyer on the need for universities in that country to enhance their role in engagement with community partners. The AASCU, representing hundreds of state colleges and universities across the USA, clearly has some clout.29 So too has the influential Carnegie Foundation – well known for its classification system since the 1970s of universities and colleges in the USA into levels of ‘research’ and ‘non-research’ – which has taken the important step since 2006 of introducing
an additional classification system of ‘community engagement’ (see Carnegie Foundation for the Advancement of Teaching 2009; also Campus Compact 2009). Parallel to this, in the health sciences, groups of concerned medical scholars in the USA have been striving to enhance the ideas and practices of engaged scholarship through university–community research partnerships, with a commission producing a first report (CCPH 2005). As the CCPH website explained:

Community–Campus Partnerships for Health has been funded by the WK Kellogg Foundation to convene a Commission on Community-Engaged Scholarship in the Health Professions to take a leadership role in creating a more supportive culture and reward system for health professional faculty involved in community-based participatory research, service-learning and other forms of ‘community-engaged scholarship’. (CCPH 2008)

And last but not least, in 2005 Campus Compact – a coalition of more than 1 000 American college and university presidents dedicated to enhancing campus-based civic engagement – organised a special conference for representatives of research-intensive universities on the issue of ‘civic engagement’ (Campus Compact 2006). With the title ‘New Times Demand New Scholarship’, the conference aimed to place the issue of civic engagement firmly on the agenda of American research-intensive universities. This led to a second conference in 2007, which homed in on definitions and debates around the question of community-engaged scholarship (see the next subsection of this chapter).

The strength of the Campus Compact movement since the 1980s has been its focus on building a student-service learning movement. This has actually been remarkably successful, and needs to be recognised as such (McMillan 2009). And in my own interview with a leading official of the Campus Compact organisation in San Francisco in 2009, she admitted that the student side of community engagement had developed far more vigorously than that of faculty (academic staff in the USA); in fact, it had been an uphill struggle for community engagement to make an impact on research-intensive universities. I would add that this is supported by evidence from the new Carnegie Foundation community engagement classification data: its list of universities that attained classification as ‘engaged’ included hardly any of the research-intensive universities that fall among the top 20 in its own classification list of research-intensive universities (comparison of Campus Compact 2009 with Carnegie Foundation for the Advancement of Teaching 2009 listings).

One reason for this uphill struggle to engage academics is clearly linked to issues of promotion and tenure. This is highlighted in the Community–Campus Partnerships for Health quote above, which places stress on ‘creating a more supportive culture and reward system’. Moreover, as noted earlier, a study by Boardman and Ponomariov (2007) of some American university research centres (URCs) – such as the highly prestigious and NSF-funded ERCs, which have been set up explicitly to build strong links with industry – found that untenured researchers were wary of jeopardising
their future careers by spending time on research reports and other work for industry, rather than on the production of peer-reviewed journal articles. Thus the reward system rooted in the traditional norms of the first academic transformation is strong at American universities, even when engineering practices linked to the triple helix are involved. This phenomenon will also be analysed in the Western Cape case studies in Part 2.

It is therefore clear that despite developments such as the science shops in Europe, or the even stronger community-engagement movement in the USA since the 1990s, the fourth helix still retains its orphan status alongside the triple helix. In addition, the battle between use-oriented U–I research activities on the one hand, and peer-reviewed-cum-curiosity-oriented research on the other, has by no means been won by the triple helix, as the findings by Boardman and Ponomariov confirm.

In conclusion, one might wonder what the impact will be in the next two decades of the pressure for ‘regional (economic) innovation,’ which may become the most powerful force for engagement, including civic engagement, affecting academic research. For example, a major thrust of support for regional engagement by top research-intensive universities has been coming from the powerful OECD, which has been driving forward ideas about the response of HEIs to regional needs (OECD 1999). Since 2005, the OECD has undertaken a series of comparative reviews of selected regions in different countries, including Korea, Mexico, Finland and Spain. These reviews aim to explicate and ‘reinforce the partnerships between [higher education] institutions and regions’ (OECD 2005a). The OECD thrusts are, importantly, accompanied by theoretical approaches to university-regional engagement, linked to the concept of a regional system of innovation, which is itself closely aligned with OECD-related theories about NSIs (as outlined in Chapter 1). Furthermore, as pointed out by Gunasekara in a valuable summary of literature on ‘the role that universities perform in the development of regional innovation systems’ (2006: 137), a central idea being taken up by organisations such as the OECD is that of the ‘learning economy’ associated with a ‘learning region’. The university is thus increasingly being viewed as a ‘regional animator’, playing a vital brokerage role in facilitating the transfer of skills and knowledge across networks of actors in the region, and also serving as ‘a conduit through which research of an international and national nature is transferred’ into the region (Gunasekara 2006: 142). And while much of the literature on regional systems of innovation views the university’s regional role primarily in economic terms, Gunasekara suggests that a more encompassing ‘university engagement’ literature sees the university ‘making a broad range of contributions to civil society, for example, in cultural and community development’ (2006: 142).

All this surely links to the importance noted by Dicken of the ‘myth of the “placeless” TNC’ and his stress on the geographical embeddedness of transnational corporations (2003: 221–235). TNCs have to be located somewhere to embed their economic operations, and a regional innovation system or learning region, linked to dynamic universities, is thus becoming increasingly vital in a TNC’s choice of location. Put
another way, there appears to be a direct link between the third capitalist industrial revolution and the new stress on ‘regional innovation systems’. Not surprisingly, in Europe there has been a rise in importance of the European Regional Development Fund since the 1990s, and in particular of the EU Structural Funds for U–I–G developments, while in the UK the Department of Trade and Industry has been strengthening ‘innovation-driven regional strategies’ (Gunasekara 2006: 137). In 2003 in the USA a group of eight powerful research-intensive universities in the Boston region (Harvard, MIT, Boston College, Boston University, Brandeis, Northeastern, Tufts and the University of Massachusetts Boston) commissioned their own impact study to explore ways in which this concentration of elite universities might enhance the ‘economic vitality of the Boston region’ (Simha 2005: 270). Underpinning this investigation was the concern of these universities and their communities that the Boston region should ‘remain competitive with other regions, including major centres in California, North Carolina, the EU and Asia’ (Simha 2005: 276).

Perhaps during the next quarter of a century, within these internationally mushrooming regional innovation systems that have U–I linkages as a core driver, the U–CS linkage will also begin to shed some of its orphan status. The next section argues that this is a need, not just a hope, if a ‘learning region’ such as the Western Cape is to achieve genuine and comprehensive development in a country like South Africa – with benefits for the mass of poor people and not just a rich elite.

**Clarifying the idea of ‘civic-engaged scholarship’**

The previous section mentioned some historical developments at South African universities during the post-1970s struggles for democracy, whereby U–CS research linkages were actually strengthened. A past president of the American Sociological Association, Michael Burawoy, was so struck by the involvement of South African university research groupings in what he conceptualised as ‘policy sociology’ and ‘public sociology’ – the latter being research with and on behalf of groups or organisations independent of industry and government – that he referred to it explicitly in his articles (e.g. Burawoy 2004). Moreover, he invited a group of South African sociologists to the annual congress of the Association in 2004 so that they could join the sociological debate which he had initiated in the USA around public sociology. Although Burawoy also noted a more recent shift after the 1990s by South African sociologists away from public and policy sociology towards what he terms ‘professional sociology’ (research and publications oriented towards other sociologists and social scientists), research work for civil society groups has by no means disappeared. Nor is such work absent from the practices of academics elsewhere, especially in Third World countries in Latin America, the Middle East and Asia.

What I wish to argue here is that despite a relative lack of intensity of U–CS research linkages at South African universities during the past decade, as compared to the previous few decades, such ‘civic-engaged scholarship’ is vital if our universities are
to increase their contribution to societal development (the third mission) at both national and local regional levels.34

There are a number of vital reasons for our universities to strengthen their U–CS research linkages. Firstly, it is important to stress that in the evolution of what has been referred to as the post-1970s ‘knowledge economy’ and an even broader ‘knowledge society’, development cannot be considered only in narrow economic terms. We need to expand Etzkowitz’s stress on the third university mission as centred on economic development to a broader notion of socio-economic-cultural development, already hinted at in earlier chapters. Admittedly, my empirical analysis of a third capitalist industrial revolution has stressed the new technological regime with its roots in ICT, biotechnology, nanotechnology, etc. – and a concomitant fairly narrow economic focus on development. Yet it is surely not incorrect to assert that the twenty-first century will see an increasing spread of new technologies derived from a much wider range of academic disciplines and fields, including the social sciences. These technologies (innovative ways of developing products or practices) might include, for example, new and sustainable forms of transport and housing, new modes of city planning, new socio-economic strategies for dealing with environmental problems, innovations in work organisation and employment creation, development of new cultural forms, and so on – in addition to the existing technologies listed in Table 3.1 which have been at the cutting edge of the third industrial revolution, and which could also have a major positive impact on the lives of poor people. Surely, therefore, university research and scholarship from such diverse academic fields could also play a major, sometimes even central, role in facilitating the development of new technologies? And surely such innovations will not be meaningful unless civil society organisations and groups are viewed not only as central ‘clients’ for many of these technologies, but – as importantly – engage with universities in diverse collaborative partnerships to help shape the nature and form of these technologies?

The last point links to a second reason why the idea of U–CS research linkages needs to shift from its current position as an orphan to occupy a central place within the third mission of universities. For implicit in my argument is the assumption that, in the new knowledge society, the forms of knowledge held by civil society groups – and also their voices – need to become part of the processes that give shape to the form and direction of the new society as it develops. The triad of U–I–G involves restricted forms of knowledge and restricted voices, which need the addition of the concerns and perspectives of civil society groups and organisations if the broad public good is to be achieved.

The third reason is less generally and internationally relevant than the previous two just outlined above. It relates specifically to a developing country such as South Africa, and to the fact that a focus on U–I–G relations assumes that industry – and implicitly its formal economy of medium and large firms – constitutes well over 50 per cent of the economic development process. This is simply not true, neither for South Africa as a whole nor specifically for the Western Cape. In this kind of
environment small, medium and micro enterprises, as well as the informal economy (e.g. domestic workers, part-time workers and small traders) and those within the survivalist sectors (e.g. sellers of fruit and vegetables and home-made crafts), make up the majority of the economically active population. This is especially true in a society in which the real unemployment rate is above 40 per cent (see discussion in Theron & Visser 2010: 3–6).^{35}

My point here is related to the views of Lorentzen and Mohamed (2009), who have argued with respect to the ‘global poor’ that about half the world’s population lives on less that US$2 a day, yet the field of ‘innovation studies’ (in which I would include the concepts of the triple helix and NSI as important elements) hardly looks at this vital group who live mostly in low-income countries or regions:

The conundrum is that the poor hardly feature in innovation studies. The large majority of innovation research focuses on how to make high income economies keep their place in the sun and how to make middle-income economies knock them off it. Very little work is dedicated to catch-up – let alone take off – of low-income countries (LICs) or regions. (Lorentzen & Mohamed 2009: 1)

These two authors argue further that most literature on NSIs focuses on the firm – while in low-income countries or regions, the crucial areas to focus on for innovation are often agriculture and health (with these areas in fact being studied by people outside the innovation studies framework).

In essence I propose, therefore, that if university researchers wish to investigate the needs of the vast majority of poor South Africans who are located outside of firms, they cannot avoid a focus on what I have termed civil society. To put it another way, only by involvement in the fourth helix of U–CS relationships alongside that of the triple helix relations will university research activity begin to make an impact on this vital majority of ‘other South Africans’.

I will end this discussion of the three major reasons for the need to enhance U–CS research relationships in the Western Cape with a summary of what I view as the actual constituents of civic-engaged scholarship, which is different to the yin-yang approach of Etzkowitz and Zhou noted earlier. Such an alternative approach can serve as an anchor for the discussions in Part 2 of this book. I propose here that the concepts of ‘community-engaged scholarship’ and ‘university social responsiveness’ assist in extracting some of the essential elements of U–CS research relationships, or what I will henceforth also refer to as civic-engaged scholarship. The following two recent initiatives have helped to explicate these concepts:^{36}

- The organisation Campus Compact (discussed above), dedicated to campus-based civic engagement, at its 2007 conference, which focused on American research-intensive universities, proposed the following definitions:

  *Community-engaged scholarship*: scholarship that involves the faculty member in a mutually beneficial partnership with the community…[and]
Community engagement: the application of institutional resources to address and solve challenges facing communities through collaboration with communities...[and]

Scholarship: teaching, discovery, integration, application, and engagement; [with] clear goals, adequate preparation, appropriate methods, significant results, effective presentation, and reflective critique that is rigorous and peer-reviewed. (Campus Compact 2007: 6)

• At UCT the draft of a social responsiveness policy drawn up by the Social Responsiveness Working Group in 2008 stated: ‘The Senate-approved definition of Social Responsiveness stipulates that it must have an intentional public purpose or benefit and activities of academic staff of a socially responsive nature should include one or more of the following: knowledge production, knowledge dissemination; integration and application of knowledge’ (University of Cape Town 2008: 2).

From these definitions it is clear that core components of the fourth helix of U–CS relations, or civic-engaged scholarship, comprise at least the following:

• high-quality scholarship from university academics (which ipso facto includes rigour and peer review, and encompasses methodologies meeting good research criteria of clear goals, appropriate methods, reflective critique, etc.);

• scholarship of one or more forms, including those of discovery, integration, application, teaching, etc.;

• engagement from both university academics (and students) and the community, with the latter collaboratively involved so that there is a mutually beneficial partnership between the university and civil society;

• intentional public benefits, which mean that, by utilising university and community resources, the challenges (social, economic, cultural, etc.) faced by civil society are addressed. This involves an agreed and explicit orientation towards the public good rather than only one party (such as a specific company or civic group) having its sectional interests advanced. This implies, moreover, that the research goes beyond curiosity-orientation (PBR); it is use-oriented in various modes (UIBR and PAR).

Interestingly, if one replaces the term ‘civic’ with ‘industry’, all the other terms and definitions seem to apply as well, that is, the fourth helix runs parallel to the triple helix, essentially referencing civic organisations instead of industry bodies. Perhaps the only difference is that issues of social justice are ignored or deflected in the vast majority of discussions embedded in the literature on the triple helix: who benefits from the engaged scholarship, or which groups gain and which groups lose in relation to the ‘public good’, are not generally posed in these definitions and analyses. Yet issues of politics, including the conception of public good, cannot be absent from engaged scholarship, whether one is considering U–I or U–CS relations (Peters 2000). The implications of this will be considered further in the concluding chapter of this book. But, provisionally, it can be stated that the components of ‘civic-engaged
The scholarly work discussed above provides a valuable framework within which to examine the few U–CS research relations which do emerge within the case studies in Part 2.

Emergence of larger research centres linked to the third university mission

In our view, there has been no more important institutional change in the past three decades of U.S. science and technology policy than the movement from department-based, principal investigator-oriented university science to a new centre-based model encouraging universities to work with industry and work beyond the strictures of academic disciplines. (Bozeman & Boardman 2004: 366)

In this statement Bozeman and Boardman make a fundamental claim: that S&T policy in relation to U–I links in the USA (their focus of study) shifted crucially after the 1970s from research rooted in the ‘little science’ of a PI, usually a professor based in a discipline in an academic department, to ‘larger science’ located in centre-based research activity, often outside the formal structures of a department. The mushrooming of research centres alongside the smaller PI-led research units or groups (or labs as they are frequently called in the natural sciences) will be the focus of analysis in this section.

The section begins by examining the significant spread of research centres in the USA in the 1980s, and then across numerous other countries, as a phenomenon directly linked to the second academic transformation, and specifically associated with U–I relations. This is followed by a short historical sociology offering some reflections on the nature of the historical transition from a ‘little science’ based on small PI-led research units rooted in the first academic transformation of the 1800s, towards larger centre- and network-type structures embedded in the second academic transformation after the 1970s. Finally, the analysis will revisit the specification of the three model types presented in the Introduction to Part 1 – the large ‘centre’ (Model A), the small ‘unit’ (Model B), and the ‘virtual centre’ (Model C) – in order to consolidate this mode of classification as the basis for analysis of the case studies in Part 2.

A turning point in the 1980s for US universities: New and diverse ‘centre types’ in synergy with a third capitalist industrial revolution

Significantly, Bozeman and Boardman (2004) link the massive growth of URCs in the USA since the 1980s to the new competitive thrust of the third capitalist industrial revolution, although they do not use this concept in their discussion: ‘In 1983, in the midst of a perceived U.S. “competitiveness crisis”, a National Academy of Science panel recommended that the National Science Foundation (NSF) establish interdisciplinary centres for engineering research. The resultant engineering research
The emergence of ERCs – six funded initially by the NSF in 1985/86 – represented a new mode of institutional design for university research. Bozeman and Boardman view this change as closely linked to what they term the ‘competitiveness crisis’ of the American economy. ‘Throughout the 1970s and into the 1980s, American industry was being outperformed by newly industrialized countries,’ they elaborate, citing South Korean steel, Japanese automobiles, Taiwanese electronics and Indonesian aircraft (Bozeman & Boardman 2004: 367).39

Even more interesting is something that came to light in their verbatim account of their interview with Eric Bloch (see Bozeman & Boardman 2004), an engineer who was NSF director in the 1980s and who played a major role in pushing ERCs onto the American university research terrain. Bloch revealed that he perceived a direct link between the ERCs and American economic competitiveness, and that to achieve such an economic thrust he believed in joining engineering research more closely to the basic sciences:40

Bozeman (to Bloch): You were on the 1983 panel that published guidelines for ERCs. Did the concept of ERC crystallize before this panel got together?…

Bloch: I think the whole focus was that in the engineering community (scientific) research was not associated with engineering. I knew about engineering, so I was appalled at this black and white idea [science versus engineering] of what engineering’s all about. Out of this concern was our focus of relating basic research to engineering…to change both science and engineering cultures…

Bozeman: If there was no competitiveness crisis it [the forming of ERCs] wouldn’t have happened?

Bloch: Yes that’s my point. The coincidence of the ERCs and competitiveness crisis is what made it come to life. (Bozeman & Boardman 2004: 371)

In terms of my hypotheses, as proposed in the first part of this chapter, Bloch is essentially arguing that around the time of 1983, for the American economy to be re-established as world leader in terms of competitiveness, university engineering research needed to become linked much more closely to UIBR (‘relating basic research to engineering’) than to PAR; and for this the ERCs were needed, as a crucial new institutional mode of research design, symbiotically linking universities to the third capitalist industrial revolution. Most importantly, too, Bloch (who was head of the NSF at the time) conceptualised the ERC design as something new, and in direct opposition to the ‘little science’ of a single professor (PI) with his or her small group of PhDs and post-docs in a lab. It is worth quoting at length from Bozeman and Boardman, in order to capture Bloch’s ideas directly in this regard:41
Bloch: George Keyworth [President Ronald Reagan's science adviser 1981–85] played a big role [in the ERC idea]. From 1983 to 1984 I had many conversations with him on competitiveness. We had a common concern. He participated in the semiconductor industry meetings. I was [at that point] representative to those from IBM. His concern was that he saw a lack of competitiveness in the semiconductor industry. This (was among the factors) that led to my becoming NSF director [1984–90], my relationship with Keyworth and our common competitiveness concerns. Once NSF director, one of the first things I did was ERCs [six already by 1986]…The idea needed to penetrate the whole engineering community. I thought twelve [ERCs] would send a message. So that was one rationale. Then when I looked at NSF (pause)…it was just the paymaster for PIs (principal investigators). I thought this was dead wrong. The idea was that NSF should be concerned about competitiveness and look for new avenues to tie together industry and government and universities [i.e. the triple helix!]. It was a new idea to NSF. The next step was doing the same thing for science centres, the STCs. But there were IUCRCs (Industry/University Cooperative Research Centres) before all this…ERCs were a different animal [‘much more research oriented…also broader in scope’ than IUCRCs, he said later in the interview]. The culture of the centres is antithetical to the PI system. (When NSF implemented the ERCs) I suspected there to be more gnashing of teeth than there was [about ERCs]. (Bozeman & Boardman 2004: 371)

As will be suggested in the next sections, there has, nonetheless, been much ‘gnashing of teeth’ by many professors at American universities – and also internationally, since the 1980s – over funding going to research CoEs and NoEs instead of to traditional university PI ‘little science’ research. However, it should be emphasised that although the ERCs were preceded by earlier types of research centres such as the IUCRCs – initiated in the early 1970s (and in effect even earlier by nineteenth-century agricultural research stations) – Bozeman and Boardman stress that the ERCs initiated in 1985, followed in 1987 by the NSF’s STCs, incorporated a very real transformation of modes of research organisation. The STCs were the natural science equivalent of the ERCs, involving interdisciplinary, university-based centres with industry links, concentrating on fundamental research and ‘…enabling researchers to accomplish challenging, longer term projects that they could not undertake at all or as efficiently as individual investigators [PIs] because of the need for stable support, large facilities or support teams or simply the need to bring together diverse experiences and expertise’ (US National Academy of Science 1987 on ‘Principles and Guidelines of STCs’, quoted in Bell & Sadlak 1992: 237).

In summary, therefore, these larger, interdisciplinary ERCs and STCs, focusing essentially on UIBR, were aimed at being a more efficient provider of research for industry than the older PI-based small units. A revolution in university research design was thus envisaged from the 1980s onwards, for reasons of economic
The universiTY in development

...comparative competitiveness in particular. Essentially, too, the centre-type research of the ERCs and STCs involved a far higher level of funding by the NSF than had been the case before. This larger, research-centre model was then taken up by the NIH and by the Department of Defense, leading Bozeman and Boardman to conclude by 2004:

- When one adds to the list the many state government-sponsored university ‘centres of excellence’ programs and the centres established by universities themselves, one finds that the university research landscape has changed remarkably during the 20 years since the ERCs were a gleam in Erich Bloch’s eye. In 1983, the academic department and its laboratories [i.e. the PI system] was the place where university research was performed. Today there are hundreds of university research centres and about one-third of academic scientists and engineers [in the USA] are affiliated with a multi-disciplinary, and often multi-university, research centre. (2004: 366)

An additional point that needs to be stressed is that not only was there this dramatic increase in the number of such ERCs and STCs and other types of CoEs across universities in the USA after the 1980s, but there was also a great variety in the forms of internal organisation and purposes of these diverse research centres. In 2003, for example, 22 new ERCs were receiving funding through the programme. The NSF was funding approximately 30 per cent of total ERC budgets, with industry, other federal agencies, universities and local states providing the remainder. Moreover, by this time there were four main ERC programme thrusts, all multidisciplinary and rooted in fundamental research. These were in the areas of bio-engineering manufacturing and processing, earthquake engineering, microelectronic systems and information technology, and manufacturing and processing. And of the 22 ERCs funded in these areas, about a quarter were inter-university (Bozeman & Boardman 2004: 368–369). This therefore indicates different areas of research, variations in funding sponsors, and complexities related to being based in one or more universities – all suggesting significantly diverse modes of internal organisation and mission (Bozeman & Boardman 2003).

There was also clearly a difference in the emphasis on UIBR compared to PAR across various ‘centre types’. For example, the ERCs generally incorporated a strong element of basic research into their use-oriented work. In contrast, from 1988 onwards, the American Department of Commerce launched an advanced technology programme in which the stress was on linkages between industry, government and university labs. As noted by Spender (1997), this programme – unlike the ERCs – focused on directly applied research.

The existence of a great variety of ‘centre types’, albeit linked to industry, was also apparent from a survey across nearly 500 universities and colleges in the USA in the early 1990s (Cohen et al. 1994). These authors located just over 1 000 centres of various types, all with some industry funding, which they classified as university-industry research centres (UIRCs). Interestingly, they found that more than half of these centres had been established in the 1980s; equally interestingly, almost
three-quarters of the 1,000 centres had been established as a result of initiatives by academics and/or their universities, with a perceived shortfall in federal funding support being a major factor in the establishment of the UIRCs linked to industry (Cohen et al. 1994: 1–2). The increasing force of industry and its funding from the 1980s onwards is thus clearly evident from this survey. But also of interest is the fairly arbitrary way that Cohen et al. chose to define this range of centres as ‘UIRCs’: ‘(1) university-affiliated research centres, institutes, laboratories, facilities, stations or other organizations; that (2) conducted research and development in science and engineering fields; (3) had a total 1990 budget of at least $100,000; with (4) part of the budget consisting of industry-sponsored funds’ (1994: 5). Their definition of a UIRC, therefore, seemed to be any (partly) industry-funded university structure in S&T fields with significantly higher annual levels of funding than ‘normal’ for PI-type small science.

By contrast, in their study of MMURCs, Bozeman and Boardman (2003) provide a definition of what they term a URC that is broader than that of Cohen et al. in some respects (because it may include non-industry ‘partners’) but also tighter (because it specifies more closely the internal organisation of the URC): ‘We define a URC as a formal organizational entity within a university that exists chiefly to serve a research mission, is set apart from the departmental organization, and includes researchers from more than one department (or line management unit)’ (Bozeman & Boardman 2003: 17).

By this definition the core distinguishing feature of a university centre is a research grouping set apart, organisationally, from any academic department and having cross-departmental researchers. It is clearly distinguished structurally from the professor-PI with a lab based inside a department. Bozeman and Boardman point out that with this definition of a URC, there is no specific requirement of multidisciplinarity or interdisciplinarity – the centre may focus on a single discipline in terms of its research work (even though many work across disciplines).44

With respect to ‘multipurpose and multidisciplinary’ MMURCs, they add the following requirements in addition to those of a URC:
• they must be multidisciplinary or interdisciplinarity in their pursuit of research;
• they must have a purpose in addition to ‘traditional’ academic research (peer review publications) typically such as working with industry, promoting equipment or research resource sharing, or engaging in technology transfer (Bozeman & Boardman 2003: 17).

Interestingly, in their MMURC study in the USA in 2003, Bozeman and Boardman found that many of these multipurpose and multidisciplinary centres were also multi-university, with a network of research groupings across more than one university.

This discussion shows that different researchers are using different criteria to define various ‘centre-type’ modes of research organisation, including ERCs, often spanning more than one HEI under Bloch’s initiative; UIRCs, especially those with industry links to higher S&T funding levels (Cohen et al. 1994); URCs separate
organisationally from any academic department (Bozeman & Boardman 2003); and MMURCs with links to ‘clients’ in addition to their multidisciplinary research. Here it should be noted that my own classification of what I have called a Model A centre type – a stand-alone centre, organisationally separate from a department, with a mission of use-oriented research – is quite close to the definition of a MMURC above, although my own definition does not insist on multidisciplinarity and moreover does not include any multi-university network structure. This centre type will be discussed further in the last section of this chapter.

It is useful at this point to turn to the empirical question of the spread of research centres as an international phenomenon beyond the USA, and thus connected to the third capitalist industrial revolution and a global competitiveness crisis, especially after the 1980s. This can further be linked to issues relating to the wide variety of forms that fall under the umbrella terms ‘research centres’ or CoEs and even NCEs.

**International spread of research centres, CoEs and NoEs**

In Chapter 1 it was noted how similar ideas about NSIs seemed to spread rapidly across different countries – essentially an ideological knock-on effect, identified by Ruivo, related to the phenomenon of the internationalisation of science policies: ‘By this we mean different countries adopting the same views and instruments of science policy’ (Ruivo 1994: 161). A similar situation seems to have occurred after the 1980s with respect to research centres: here, the ‘instruments’ encompass larger university-based research groupings or what have been called CoEs or NoEs. For example, Bozeman and Boardman, in their study of ERCs under the NSF, pointed out that:

…just a few years after the ERC implementation in the United States, the United Kingdom implemented a program based explicitly on the ERC model. The Science Foundation of Ireland (SFI) not only set up its program Centres for Science, Engineering and Technology but recruited former director of the National Science Foundation’s Science and Mathematics Division, Dr. William Harris, to serve as SFI Director General. (Bozeman & Boardman 2004: 370)

I would argue, however, that more fundamental than this common ‘global ideology’ of science policies focusing on NSIs and the importance of building CoEs, is the pervasiveness of the underlying idea of a competitiveness crisis. It is my thesis that this notion of economic competitiveness is the fundamental driver of the international spread of larger research centres and networks as modes of research organisation. In other words, the mushrooming of new modes of university research is directly linked after the 1980s to the third capitalist industrial revolution in Europe and elsewhere. In relation to Europe, for example, it has already been mentioned that the European FP5 of 1998–2002 emphasised the funding of larger research networks across countries of the EU, to give reality to the vision of a common ERA. It has also been observed that FP6 of 2002–06 stressed the building of NoEs, which I shall later refer to as ‘virtual centres’. And, as pointed out by Delanghe and Muldur (2007),
these NoEs were larger and had their roots more strongly within universities, compared to the FPs which had emerged in the 1980s and 1990s:

...while the number of [research] projects and participations increased continuously from one FP to the next, it was only under FP6 [including its NoEs] that individual projects and participations became decisively larger in financial terms and evolved towards reaching ‘critical mass’... [And the] participation structure evolved from one dominated by firms to one marked by a more balanced participation by different kinds of S&T actors...especially those from universities and research institutes, now accounting for most FP participations and funding. (2007: 175–176)

It has moreover been noted that in Europe, from the time of FP1 in the mid-1980s, the issue of economic competition has been a central driver of FP funding initiatives, with the ‘Lisbon Strategy’ of 2000 explicitly setting the goal of the EU becoming, by 2010, ‘the most competitive and dynamic knowledge-based economy in the world’ (EU declaration, quoted in Luukkonen et al. 2006: 239).

In this regard it is relevant to comment briefly on some of the ‘country’ sections of a report by the Academy of Finland (Malkamaki et al. 2001), which produced an interesting collection of data entitled ‘Centres of Excellence Policies in Research: Aims and Practices in 17 Countries and Regions’. This provides a useful window through which not only to view the spread of research centres across a range of countries, but also to assess the diversity of research groupings that fall under the umbrella of CoEs. For example:

...the Finnish Programme for Centres of Excellence in Research (CoE Programme)...was launched in 1998...[A] centre of excellence is made up of research teams that share the same objective and have a common leadership, even though they may be part of different organisations and be based in different parts of the country...The [awards in 2000 of the] Finish CoE policy yielded 26 relatively small research units (with personnel numbers ranging from 20 to 100, the average being 50), a few of which are virtual. (Malkamaki et al. 2001: 7)

Although the term ‘small’ is used here, in terms of my own classification of centre types noted earlier, an average size of around 50 is clearly far larger than what I have termed the ‘traditional small unit’ of a PI-led group comprising a professor plus a few postgraduates and post-docs. And some are clearly best viewed as NoEs, comprising researchers from a number of universities and other research organisations. Of relevance here, too, is that the Academy of Finland report (Malkamaki et al. 2001: 35–41) shows that the 26 Finnish CoEs (selected competitively from 166 outline proposals) were established for a six-year term (with possible funding extension), with almost all having their lead researcher based at a university or university of technology. Thus, the university system of Finland was central to the new initiative, and these centres spanned fields as diverse as the ‘Formation of Early Jewish and Christian Ideology’ and ‘Forest Ecology and Management’, though most were in
S&T fields. Crucially, awards of CoE status stressed standards of ‘top international research,’ but at the same time clearly aimed to ensure Finnish economic competitiveness by means of what was, in effect, the third mission of universities: ‘The objectives of the [CoE] Programme are to create the information base required for cultural, social and industrial development, and to create a solid base for a national innovation system’ (Malkamaki et al. 2001: 35).

In essence, therefore, we can observe in Finland in the late 1990s the launching of a programme of university-based CoEs with some spanning of networks across universities, and with all rooted in what I term UIBR – quality basic science research but with an ‘eye out’ for Finland’s insertion into a ‘knowledge economy’ and a world of economic competition.

Cases of CoE development in western European countries such as Austria (after 1992), Denmark (after 1991), Ireland (after 2000) and Switzerland (after 2000) showed similar specific policies (Malkamaki et al. 2001). In addition, the EU initiated specific support for CoEs in the central and eastern European countries of the previous ‘socialist bloc’, as part of its FP5 of 1998–2002, stressing the building of networks between these research centres and their western European research counterparts (Malkamaki et al. 2001).

Some countries in Asia – for example, South Korea from the late 1980s – have pursued a particularly clear policy of developing university CoEs. In others, such as China, Japan and Taiwan, the situations have been more diffuse – partly because significant research institutes or centres already existed outside the universities, for example within government structures and even within industry itself, as in Japan (Malkamaki et al. 2001).

But from the 1990s onward, all of these Asian-cited countries have, as mentioned in Chapter 1, focused on research policies that included expanding and consolidating university-based CoEs of various forms. South Korea, in fact, has provided the clearest example of building CoEs within its universities as part of its economic competitiveness strategy. In this country there was a proliferation from the 1970s of non-university industrial research institutes, but 1989 saw a shift, with research excellence concentrated in major universities through science research centres (SRCs) and ERCs (see Ahn 1995). These SRCs and ERCs comprised a CoEs programme of the Korea Science and Technology Foundation, a subsidiary of the Ministry of Science and Technology, which had been set up after 1977 to promote ‘basic research in natural science and engineering’ (Ahn 1995: 245). Both the SRCs and ERCs were required to cooperate with industry-based research units and government-related research institutes and also, wherever possible, with international research groups (Ahn 1995: 248–249). By 1995, 35 CoEs had been established across 14 universities, with each CoE collaborating with an average of 10 industrial companies. By 2001 the number of CoEs was well over 60, with between 12 and 39 researchers in each centre (Malkamaki et al. 2001: case 14), that is, a considerably larger structure than a traditional PI-professor lab.
In some Latin American countries, too, at least since the 1970s, relatively large research institutes and centres have been set up, some affiliated to universities and some not. This has been influenced in part by the historically heavy involvement of academics in teaching, which has left them with relatively less time for research (for Brazil see Dagnino & Velho 1998; for Mexico, Jimenez & Zubieta 2002; also Schwartzman 2008).

Finally, it should be noted that some of the strongest steps towards establishing CoEs under the umbrella concept of an NSI have occurred in Australia and Canada, linked to a broad range of other research enhancement policies focusing on U–I links, some of which were mentioned in Chapter 1. Australia has seen a series of thrusts in the development of CoEs, such as the Cooperative Research Centres (CRC) programme (begun in 1990), and the Key Centres of Teaching and Research (KCTR) programme (begun even earlier, in 1985), to enhance industry training and research needs (Tegart 1996). Of note have been the Special Research Centres, initiated at universities as early as 1981, based on research excellence – although ‘relevance’ increasingly became a criterion in the 1990s (Van der Meulen & Rip 1994). Already by the mid-1990s the programmes of Special Research Centres and KCTRs comprised 10 per cent of the Australian Research Council budget (Tegart 1996: 163), while a broader survey around this time of nearly 1 000 diverse types of ‘centres’ at Australian universities showed that about two-thirds had sprung up between 1989 and 1993 (1996: 162).

I will end this review with comments on the case of Canada, not least because the initiatives over the past few years of the South African National Research Foundation (NRF) and Department of Science and Technology (DST) – in establishing larger CoEs and smaller ‘research chair’ forms of organisation – have been significantly influenced by the Canadian experience of such structures.

It seems that Canada itself was influenced by its American neighbour (Bell & Sadlak 1992: 36–37), where University Industry Cooperative Research Centres were initiated by the NSF in the 1970s, followed in the 1980s by even bigger NSF thrusts via the ERCs and STCs. In the late 1980s, the Canadian federal government initiated its own pilot programme of 14 CoEs. Bell and Sadlak described the CoEs as interdisciplinary, usually multi-university (i.e. involving a network structure of researchers), with a focus on fundamental research for technology development. They explained that, although industry was not a major funder, it influenced research directions through its representatives on each CoE’s board of directors (Bell & Sadlak 1992: 37).

The programme became permanent in 1997 and, at the time of the Finnish survey, 18 networks of CoEs were being funded, for two consecutive periods of seven years (Malkamaki et al. 2001: 20–25, case 4). In a critical commentary on what Fisher et al. (2001) refer to as the NCEs in Canada, they make a number of very valuable points which link directly to questions about some of the South African research policy initiatives on university research chairs and CoEs that will be considered further in Parts 2 and 3 of this book:
• The Department of Industry, Science and Technology Canada (later renamed simply ‘Industry Canada’) set up the NCEs as ‘virtual-type centres’ connecting groups of researchers from different institutions to industry, rather than as ‘fixed-type centres’ (each located in a university) – partly because fixed-type centres would have been more expensive to create across the country (Fisher et al. 2001: 310). At another point in their discussion, Fisher et al. refer to these NCEs as ‘research institutes without walls' (2001: 322), highlighting their virtual nature. This raises a question for South African universities about the South African NRF initiative begun in 2004 to establish a series of what they have termed CoEs, ‘virtual centres’ of similar form to the Canadian NCEs, generally spanning research groupings across more than one HEI and with research linked to industry. How valuable is this compared to the building of fixed-type centres, or what I have called Model A centres within each university, which are different from network structures (what I have called Model C ‘virtual centres’)?

• These NCEs were part of the emerging, broader Canadian system of S&T initiatives called InnovAction (Fisher et al. 2001: 300). As noted in Chapter 1, Fisher et al. put it thus: the ‘NCE is an ideological instrument…to change the research culture’ and it is via this ‘network science’ that ‘academics must be enlisted in the “national system of innovation”’ (2001: 322). Moreover, they suggest that the term ‘pure, long-term applied science’ used in the 1990s by some Canadian officials in relation to developing the NCEs fitted closely with the idea of UIBR derived from Stokes. However, Fisher et al. (2001: 316) do argue that later in the 1990s a greater ‘applied research’ emphasis emerged in the NCE programme criteria, although these did retain basic science components. Part 2 will show that there have been similar occurrences in South Africa: our DST and the NRF in recent years provided important policies and support to enhance research at our universities, but with most linked directly to a package of ideas framed by views of ‘our NSI and economic competitiveness’. A question therefore arises: to what extent have these perspectives in South Africa (and also clearly in Canada) tended to overstress PAR at the expense of UIBR at our universities, for example in biotechnology and space research in the Western Cape case studies?

• Each Canadian NCE included two core dedicated positions: a scientific director for each network to coordinate and integrate the research projects, and a network manager who focused on budgets, graduate students, industrial contracts, reporting, and so on (Fisher et al. 2001: 317). Turning again to South Africa, an important question to be explored throughout the case studies will be whether the larger research centres (Model A type) and virtual centres (Model C type) in the Western Cape were adequately provided for in terms of funding for research directors and research project managers.

It should also be pointed out that, parallel to the Canadian NCEs, a programme was launched in 2000 that focused on Canadian research chairs – in effect funding PIs and their small teams of doctoral and post-doc researchers alongside the NCEs. By 2006 almost 2 000 such professorial chairs were being funded (Charette 2008) – the year in which the South African research chairs initiative (SARChI) was launched, modelled on the Canadian research chairs programme, with the aim of eventually
creating 210 similar South African chairs, each structured around a PI. An important question to be considered in later chapters is the following: has there been a self-conscious awareness in SARChI that such policies in effect support what I have termed the Model B small-unit type, rooted in a professor-chair and postgraduates-plus-post-docs structure, rather than developing new larger types of centre as part of the international movement observed in the analysis above?

In conclusion, two points need to be highlighted in this discussion of CoEs as a global form of research organisation since the 1980s. Firstly, the international cases mentioned above do provide very clear evidence that larger ‘centre-type’ research organisations have been supported across a wide range of countries over the past three decades. This has been partly due to the reasons already given for the establishment of STCs – especially in the USA – in 1987, namely (as cited above from ‘Principles and Guidelines of STCs’, quoted in Bell & Sadlak 1992: 237):

• ‘enabling researchers to accomplish challenging, longer term projects’, which could not be undertaken ‘at all or as efficiently’ by the ‘little science’ of PIs;

• which is itself linked to the need for ‘stable support, larger facilities or support teams’; and

• also simply to ‘bring together diverse experiences and expertise’.

All these are vital efficiency factors to be examined in the Western Cape cases that follow. However, it has also become clear that centre-type research has by no means simply taken over from PI-professor small-scale research work. On the one hand, the spread and consolidation over the past decade of Canadian research chairs, based around PIs, suggests clearly that this is not always the case. In addition, a number of CoEs – under a variety of names, such as IUCRCs (USA), CRCs (Australia), NoEs (Europe) and NCEs (Canada) – in fact often appear to be little more than networks linking a series of PI-professor small research groups. In other words, they are de facto ‘virtual centres’ comprising a cooperative linking together of a set of small labs or groups. What therefore seems evident is the strength or tenacity of the historical structure of PIs rooted in the first academic transformation of the nineteenth century, which, when faced with new forces of change, maintain themselves (as new ‘research chairs’, albeit with a third mission), or adjust like chameleons to become seemingly new structures of networks (but with PIs as core elements of the network).

In only some cases does there appear to be a ‘real centre’ or what I have termed a Model A ‘stand-alone’ centre type, defined as a set of research subgroups or teams (often two to six in number), all under a single director, and located as a structure within a single university. Examples of these are suggested above with reference to the South Korean STCs/ERCs, the Australian Special Research Centres, and some of the STCs/ERCs in the USA. It is clear that this centre type, and its potential efficiency and relevance, needs to be examined closely in some of the Western Cape cases. This is particularly so because the South African policy thrusts over the past decade have been to develop other types of CoE (multi-university, virtual centres along the lines of the Canadian NCEs) and even more recently, research chairs (thereby seemingly consolidating small unit types).
Thus it is clear that CoEs have mushroomed internationally as part of a second academic transformation, in a variety of forms ranging across a spectrum of 'real' and 'virtual' centre types. Yet, parallel to this, the small-unit type research group, rooted in a PI or professor-chair, seems by no means to be a vanishing mode of research organisation within many academic departments internationally.

A second significant point with respect to the discussion above is that not all countries have seen a growth of CoEs in the forms described in this chapter. While what might be called a 'CoE movement' has undoubtedly been observed across numerous countries and continents since the late 1980s, it should be noted that the way this unfolds depends crucially on each specific historical and socio-economic-cultural context. For example, in France after the Second World War there emerged, outside its university system, government-funded research organisations such as the Centre National de la Recherche Scientifique (CNRS). Within the CNRS, large groups, centres and laboratories undertook research without having undergraduate (and often not even postgraduate) teaching duties. Writing in 2004, Laredo and Mustar pointed out that, although the CNRS had become the biggest institution in the EU dedicated in part to fundamental research, over the previous two decades there had emerged twice as many full-time equivalent researchers in French universities as in the CNRS (30 000 against 14 000; see Laredo & Mustar 2004: 16). They noted, moreover, that:

…four-fifths of CNRS research units are ‘mixed’ between CNRS and the universities; they are located on university campuses and employ more than four-fifths of all CNRS personnel. The 1,200 units that comprise CNRS now mobilize more than 60,000 persons, each unit having on average more university staff than CNRS researchers. Overall the centre of gravity is shifting towards the universities. (Laredo & Mustar 2004: 20)

In France we therefore see a complex evolution of networking/semi-merging between university and CNRS research groupings, which cannot easily be classified under a simplistic concept of stand-alone CoEs or even well-defined NoEs.

In Germany, too, there has been a complex historical situation associated with the Max Planck Institutes (MPIs), which fall outside the university system and whose focus has been on world-class basic research. But there have been strong moves since the late 1990s to link the Institutes more closely with university research groupings. Moreover, this national terrain has been further complicated by the non-university research structures of the Frauenhofer Gesellschaft (for industry-related R&D), the Blaue Liste (Blue List, with diverse research missions), and the Hermann von Helmholtz Association (for applied research). As with France, no simplistic template of a 'shift towards CoEs' fits here, although after 2006 the German government initiated competitive awards for additional federal funds, in part for universities to bid for the establishment of CoEs. Initially, 41 awards were made to establish such new centres (Kehm 2006: 20–21).
Despite all the above qualifications, however, it is nonetheless useful to end this discussion with a quotation which highlights the fact that since the 1990s – at least across Europe, and by implication more widely across other continents – there have been closer linkages between universities and their local regions, as well as a clear shift toward larger research centres and more networking between research groupings, as stressed throughout this section:

In a growing number of Member States [of the EU], policy for higher education and research is now being shared between national and regional governments; and in nearly all, regional innovation policies are booming. This has developed alongside an increasing interest in national governments and the EU in ‘problem-solving’ policies, which are moving public-sector research away from individual projects, towards centres and networks of excellence. (Laredo & Mustar 2004: 26)

A historical sociology of the consolidation of research centre types after the 1980s

This section provides a theoretical reflection on some of the empirical data on centre types presented in the last section and also on MIT and other universities discussed in the previous chapters. I will present a schematic theoretical interpretation – a brief historical sociology – of the transition from a professor-led small research unit, a core element of the first academic transformation of the 1800s, to new centre-type structures, which I see as central components of a post-1970s second academic transformation. This ‘long historical’ theoretical approach provides a perspective on why, as suggested in the previous section, the PI-led unit type maintains its strength and tenacity even after the big academic changes of the past three decades. This Model B small-unit type has a history (and a supportive system of values and procedures within academic departments) of about 200 years of PBR. This is much longer than the relatively new larger Model A and C centre types, with their focus on UIBR and PAR as part of a new third mission. I hypothesise, therefore, that one should expect a degree of ‘chaos and creativity’ because of the (as yet) relatively weak supportive research systems of values and procedures around these emerging new centre types. Thus one might expect that in the Western Cape case studies, Model A and C centres would continually bump up against the forces of disciplinary departmental norms and structures, including the power of small unit-type research groups. The brief theoretical discussion that follows is by no means comprehensive but is sufficient to set up a necessary framework for the analysis in Part 2.

A sobering point with which to begin the discussion is the conclusion reached by Bozeman and Boardman in their article on the Eric Bloch interview. Despite their assessment of Bloch’s resolve, as the new director of the NSF, to ‘go into battle’ in the early 1980s with centre-type ERCs and STCs against an NSF that he saw as ‘just the paymaster for PIs…I thought this was dead wrong’ (Bozeman & Boardman 2004: 371), nearly 20 years later in 2004, they still considered this battle by no means won:
To some extent the jury is still out regarding the ability of these innovative institutional designs [centres such as ERCs/STCs] for research and education to co-exist with traditional university structures [like the PI system] created hundreds of years ago and little changed since. But the revolution [of such new centres] has begun. (Bozeman & Boardman 2004: 374)

In his empirical investigation of two American chemistry departments nearly two decades ago in the early 1990s, Etzkowitz reached the following conclusion:

The team [a 'little science' research group or unit within these chemistry departments] is made up of a 'principal investigator' and a group of colleagues, many of whom are still students or in the early stages of their scientific careers...[An] academic department in the sciences consists of a series of such [PI-led small] groups organized by its teaching staff. Indeed, the ability to organize and obtain support for a group has become a tacit requirement for appointment to permanent tenure. (1992: 28–29)

And later, when discussing this small 'team,' he states: 'Virtually all our respondents [from such research teams in the two USA chemistry departments] strongly supported the 'individual investigator' as a way of doing science, arguing that it was both more efficient and productive than large-scale approaches' (Etzkowitz 1992: 46).

The tenacity of this 'little science' research model will be considered below in relation to two countries in which it has played a particularly powerful role in academic practices, Germany and the USA.

**Germany**

What exactly are the historical roots of the undoubted strength of this 'little science' unit or group around a professor 'individual investigator,' and how is it linked to our long-standing academic teaching and research structures and systems of tenure? One must begin, I suggest, with Etzkowitz's ideas about the first academic transformation of the 1800s, where he stressed the joining together of the first mission (teaching) with the second mission of (basic) research (though he did not himself link this directly and theoretically to the 'individual investigator' mode). As mentioned in Chapter 2, the early 1800s in Prussia saw a series of what were termed the Humboldtian reforms of universities. This was the time when the science of new knowledge – what Boyer (1990) has called the 'scholarship of discovery' – began to blossom, in central Europe in particular. In fact, it was also associated with the emergence of a new type of German professor, who worked in a narrow subfield linked to the new disciplines of investigation and trained PhDs in his (they were all men) 'lab.' As perceptively put by Turner:

The modern academic tacitly assumes that discovery arises normally from research, that is, from the systematic application of definite scholarly techniques to some limited area of investigation for the purpose of extracting
critical knowledge...In fact the very concept of research in its familiar form seems not to have been clearly articulated before 1790. (1975: 528)

The thrust of Turner’s article is that the vast majority of semi-feudal (pre-French Revolution) German scholars of the mid-1700s valued instead a ‘scholarship of a broader, more synthetic’ nature (1975: 523), of wisdom and insights, valued by ‘one’s corporate fellows’ across a wide range of fields – such as philosophy, metaphysics, theology, and even history and languages: ‘[They] perceived creativity in a far wider range of scholarly activities. In particular they refused to equate scholarly creativity with discovery alone’ (1975: 525).

By the mid-1800s, however, the Humboldtian reforms had taken root in Germany, with the professor-chair as the anchoring system (Busch 1962) for this mode of research based on the new disciplines and the narrower concept of scholarship.53 The professor-chair structure, as a core of this academic transformation, functioned as follows: a professor, who would usually be over 40 years old, would be awarded a chair by open academic competition, after a long period of post-PhD study leading to numerous publications and an oral examination (the ‘second doctorate’ or Habilitation). The ‘chair’ (see Enders 2000: 26) held by a full professor or Ordinarius was (and still is) awarded for life to an academic-head-as-civil-servant, and included funding for ‘research of discovery’ (Wissenschaft). This would pay, in part, for PhD research assistants, post-docs and untenured researcher-lecturers known as Privatdozenten (working towards or having completed the Habilitation).54 Combined with the research work, the professor (with his assistants) would also fulfil the required teaching duties of such a ‘chair’ within the university.

Importantly, too, the German research chair was (and is) termed an ‘institute’, with funding from the state negotiated at the time of the appointment of the incumbent (Enders 2000: 26). These institutes function, in effect, as ‘little science’ research groups or labs of a professor with a team of untenured research assistants clustered around him or her – PhDs, post-docs, technicians and, in the German case, a few Privatdozenten. As Enders puts it: ‘In the early twentieth century, the concept of Ordinarius, which combined the chair with the directorship of an institute, was considered suited to integrating Humboldt’s concept of the university [combining teaching and research] with the requirements of small-scale research and territorial state administration’ (2000: 26).

In summary, therefore, there really was a first academic revolution as Etzkowitz has termed it, led by the German universities in the 1800s after the French Revolution. But this was a deeper transformation than suggested by Etzkowitz, more than the joining together of research with teaching; instead, a new and narrower concept of scholarship (essentially PBR) alongside the consolidation of the professor-chair or German small institute system was created which would have the most significant and far-reaching effects.
America

What was the situation around 1900 in the USA, where the German system of ‘research of discovery’ and high-quality PhD training at graduate level had provided a reference point? In the USA such a system was constructed ‘on top of’ the undergraduate college system, rooted in significant undergraduate teaching (see Chapter 2). Because of this, instead of the German chair-cum-small institute under the leadership of one director, a system of larger discipline-based departments emerged in the USA, often having more than 20 tenured academics. Nevertheless, by the early 1900s, research within each academic department had come to be based firmly around one professor, in the mode of professor–PhDs–research assistants. In other words, the German small ‘institute’ was reproduced at the level of the individual American professor, but within a larger department. And while teaching organisation was essentially under the control of the department, research direction and control was primarily located within each small unit led by a professor-PI. This is also evident in the quotation above from Etzkowitz (1992), in which he argues that the tenure of professors de facto depended on their attainment of a viable mode of ‘little science’, with funding acquired for themselves and their groups of research students or research assistants.

Here, therefore – before the First World War – was the essence of an internationally based PI research system, which had originated in Germany well before 1850 and spread across European universities and into the USA and elsewhere. The small ‘PI-professor research unit’ was a powerful international model throughout the twentieth century, rooted in German-style, self-confident, well-paid, high-status professors, many of whom had national and even international reputations for research excellence. Erich Bloch – who came to the NSF directorship from IBM and who never obtained a PhD himself – was thus very aware that this international cohort would begin a ‘gnashing of teeth’ when funding became available for a more broadly based system of larger research centres, which he instituted for the new ERCs and STCs in the 1980s.

It is nevertheless important to bear in mind that research centres and, more generally, ORUs, did not come suddenly onto the scene after the 1970s, although they certainly expanded enormously thereafter. Geiger’s historical investigations of the USA are especially relevant here. He shows that the latter half of the nineteenth century saw the first ORUs at universities and elsewhere in the USA, in the form of observatories, natural history and archaeology museums, and agricultural and engineering experimental stations (Geiger 1990). Before the First World War, moreover, there had emerged a few larger university research labs – such as the applied chemistry lab at MIT – and one or two institutes of oceanography (Geiger 1990: 6, Table 1).

In the interwar period the number of ORUs increased somewhat, and in addition there emerged larger laboratories in fields such as aeronautics, health, engineering and occasionally even in the social sciences (Geiger 1990: 6, Table 1). Nonetheless,
Geiger’s assessment is that, up to the Second World War, the core business of the American university system was teaching, with his central argument being that:

…ORUs during this era [the interwar period in the USA] remained exceptional; that is, they were not perceived to be a special administrative concern, and they did not affect enough researchers to be regarded as a significant departure from existing practice. This situation changed decisively as a result of the Second World War. (Geiger 1990: 7)

Until the Second World War, therefore, the system that dominated each department at American research-intensive universities was ‘little science’ research around a professor-PI within a department – as part of his or her normal ‘existing practice’ to attain (and sustain) tenure, alongside expected teaching duties as lecturer-professor.

Admittedly, the Second World War was an ‘academic turning point’ that briefly shook up the ‘little science’ PI situation, with American universities and some of their science and engineering professors in particular being drawn into the war effort, especially through UIBR, as argued in Chapter 2. This war research to some extent thus saw a qualitative shift in a few sites away from the individual professor as PI, towards a network and sometimes a ‘centre organisation’ of PIs. Some professors moved to join large research teams at other universities – the most striking example being the Manhattan Project, which involved over 1,000 scientists and engineers.

However, once the pressure for such extreme ‘mission-oriented’ research for the war effort had subsided, and under the Vannevar Bush ‘ideology of unconstrained basic science’ supported by massive post-Second World War federal funds, there was – as mentioned in the previous chapter – a relative shift back to PBR, mainly around the PI mode of research at universities. This continued for some decades after 1945, with the ‘little science’ mode expanding and dominating across many new research universities, alongside the pre-war elite of research universities (Geiger 1990).

However, as Geiger (1990: 3) notes, in the decades after 1945 new modes of research based on larger centres and networks emerged, especially within and across some American S&T departments – as observed in Chapter 2 for Stanford, where engineering-physics research blossomed under the leadership of Professor Terman after the Second World War. And as Etzkowitz insightfully suggests with respect to these Stanford developments, such research centres, even those of a ‘network of professors’ type, embodied certain vital aspects, two of which I will stress through the case studies in Part 2:

• a collective mission that sets direction for all research undertaken by, especially, the senior researchers within a centre;
• a new layer of post-PhD research workers with the career orientation of research only, that is, their self-identity is ‘researcher’ not ‘researcher-lecturer’.

As Etzkowitz puts it:

The formation of centres, such as the one at Stanford, during the early post-war era brought together a group of individual investigators to
pursue a common area of research and connected them with a funding source to pursue their objectives...[Professors] keep their research groups going with their existing sources of support but above and beyond that is another layer of research activity which they organize jointly. Nevertheless, there is an element of collectivization introduced, even some aspects of the [research] institute system appear. The decision-making is collective among researchers; fund raising is also done jointly. In addition to graduate students and post-doctoral fellows doing the research for delimited periods, full-time researchers, with a PhD, who are otherwise qualified to be a faculty member, are also hired...but without the autonomy accorded a junior professor to go out and seek research funds for self-initiated projects. (1994: 81–82, my emphasis)

This quote clearly captures the idea that ‘centre-type’ structures result in an emergent ‘new collectivisation’ introduced at a higher level – as ‘another layer of research activity’. The larger research centre, as a ‘whole structure’ led by a centre director, thus operates in terms of a central mission, driven by its collective funds. This means that each professor-led subgroup cannot simply do their own thing – as would be the case in self-initiated projects typical of a PI-professor, who has financial control of her or his group. This defining idea of ‘constraint on research subgroups or teams within a centre’ is pursued in the next section, especially in the definition of a Model A-type ‘real centre’, but also to a more limited extent in the Model C-type ‘virtual centre’ as a network of professors.

It is important also to stress the further point embedded in Etzkowitz’s observations above: that such collective-mission centres not only started becoming consolidated at places such as Stanford (and MIT) after 1945, but they also began to establish a ‘career line for research scientists with specified appointment procedures, and appointment grades and terms’ (Etzkowitz & Kemelgor 1998: 282) – a career track for ‘researchers’ alongside the traditional tenured track for ‘researcher-lecturers’. This was, for some, a welcome development – for example, at MIT itself a robotics specialist ‘refused a tenured professorship, preferring research in a centre, with no teaching and administrative chores’ (Etzkowitz & Kemelgor 1998: 282). Overall, however, I have argued that before the 1980s in the USA such a research-centre mode of functioning, with a funding-defined mission and career tracks for pure researchers, was still embryonic. And during the decades up to the 1970s, such new centres faced uphill battles with many academic departments and their PIs within American universities. For example, as Etzkowitz discovered from his 25 interviews with professors in two American chemistry departments, even in the early 1990s ‘[m]ost investigators felt their way of life threatened by the shift in interest of agencies which provide financial support to centres’ (1992: 47). This led him to conclude that academic chemistry is ‘at a crossroads between the traditional “little science” research group and the more highly organised patterns of “big science”’ (Etzkowitz 1992: 44). In the same article in which he reported that a MIT robotics specialist chose research in a centre rather than a tenured researcher-
lecturer professorship, Etzkowitz notes: ‘In another instance, departments objected sufficiently to bring a new centre to a halt. Despite gaining funds for a center building, a leading scientist appointed by the university could not overcome the resistance’ (Etzkowitz & Kemelgor 1998: 276).

Thus we do see the emergence of larger research centres in selected universities, especially after 1945 in the USA (and also in Europe and elsewhere), but the floodgates only burst after the 1980s. During the three decades since the 1980s we have seen a significant global expansion and consolidation of research CoEs, NoEs and NCEs, not only in the USA but widely across a number of continents as the second academic transformation unfolds. This sets the scene for an analysis of the ‘creativity and chaos’ faced by some South African research centres, as they sought to consolidate themselves after 2000, against what I term the ‘historical forces of the first academic transformation’ within their Western Cape universities.

Defining more closely the internal organisational structure of ‘research types’: Models A, B and C

Having established a clear framework for the historical development from the first to the second academic transformation – with new research structures bursting forth since the 1980s – it is now relevant to return to the propositions about use-oriented Model A, B and C research types put forward in the Introduction to Part 1.

Figure 3.1 Research model types of the first and second academic transformations
Figure 3.1, based on the schema outlined in Figure i.4 of the Introduction to Part 1, is provided here in order to position the ideas of the first academic transformation/PBR (curiosity-oriented research) in relation to the second academic transformation/UIBR+PAR (use-oriented research). The cases referred to in the figure are among those presented in Part 2 of this book.

This section will seek to define more closely the internal organisational structures of the three use-oriented models, hypothesised as comprising larger centre types on the one hand (Models A and C) and a small-unit type on the other (Model B). It will thus provide the conceptual tools needed to explore Cases 1, 3 and 2 respectively in Chapter 4.

Corley et al.’s (2006) point about MMURCs (often also spanning universities in the USA) is pertinent here. Despite the significant post-1980s international expansion of such larger centres, an understanding of the internal organisation and management of these research structures has not kept up with these developments:

> Over the past three decades, U.S. science and technology funding agencies have increasingly supported large-scale, centralized, block grant-based research projects that often span multiple disciplines and institutions. This trend has developed at such a rate that research focused on understanding the management of these new collaborative models has largely not kept pace. (Corley et al. 2006: 975)

This section and the whole of Part 2 take seriously the implicit exhortation of these authors to investigate rigorously the modes of organisation of the new research-centre types (and new unit types). The aim is to gain a greater understanding of their internal structures and forms of management, something that is also important in relation to the broader concern of this study, namely the factors that enhance and inhibit the work of the Western Cape research groupings examined.

Model T and Model B: Traditional and new small-unit types

The historical analysis in the previous section of the professor-chair PI-unit structure that emerged in the 1800s as the foundation for the first academic transformation, and its ‘knowledge of discovery’ orientation, enables one to make broader sense now of the features of Models T and B, as summarised in Figure 3.2.

It is important to note that ‘traditional’ here has a specific time reference – to the first academic transformation of the 1800s, extending into the 1900s internationally. It does not refer to the pre-French Revolution forms of scholarship, which, as suggested in the previous section, involved even earlier and ‘more traditional’ forms of feudal-university scholarship.
Figure 3.2 A shift to use-oriented research: Maintaining the core internal organisational structure of the small PI-unit

(Curiosity-oriented)
PBR

Model T
Traditional (Virtual) Unit

In a lab or small group
Postgraduates & a few post-docs

Professor
researcher-lecturer
as principal investigator (PI)

First academic transformation

(Use-oriented)
UIBR+PAR

Model B
New (Real) Unit

In a lab or small group
Postgraduates & a few post-docs

Professor-researcher
as principal investigator (PI)

Second academic transformation
The hypothesis which will be explored with reference initially to Case 2 (and later to Cases 4 and 5) of the Western Cape in Part 2, is that the Model B type is oriented to use-oriented research and its third mission, while retaining the same, almost unaltered unit structure as shown in Figure 3.2 for Model T. For, as can be seen, Model B with its use-oriented research (UIBR+PAR) linked to external stakeholders or clients (e.g. industry or civil society) maintains the same internal small group/unit structure of tenured professor-cum-postgraduates-cum-post-docs. Like Model T, it is situated in a physical lab or (more generally, for example in the social sciences) as an informally constituted group. And in addition, like Model T, it is often (but not always) located within an academic department in which the professor-PI (as head of unit) is located. But, importantly, the professor-PIs of both models have a high degree of autonomy over the control of their small unit and its research direction and research funds (vis-à-vis their department).

As suggested in Figure 3.2 (and as will be investigated further in Chapter 4), there often appear to be only a few differences between the two models (besides the important one of curiosity-oriented versus use-oriented research). Examples of such differences are the following:

- While the traditional Model T unit type is usually very informal and hence what I term ‘virtual’, the Model B type frequently seeks, linked to its third mission focus, a more formal and recognised designation as a unit within its university and then becomes what I term a ‘real’ unit with an official research title.
- Often the Model B professor, under pressure from third mission work, sheds an undergraduate teaching load, becoming more a full-time professor-researcher rather than a professor-researcher-lecturer as in the traditional Model T unit.

Thus, one model type we see emerging in relation to use-oriented research and the new second academic transformation has an almost untransformed traditional professor-PI unit structure. It is further hypothesised that under certain conditions Model B units can pursue their third mission activities as effectively and efficiently as the larger centre-type structures. This point will be discussed further with reference to some of the cases in Part 2.

**Model A: A new centre type**

A second hypothesis, to be explored initially with reference to Case 1 (and later to Cases 6 and 7) in Part 2, is that with the second academic transformation we are also seeing a quite new and different model type emerging, a Model A centre type, with an internal organisation as illustrated in Figure 3.3.
Figure 3.3 A radically new internal organisational structure of a ‘real’ centre

As discussed in the Introduction to Part 1, the concept of this specific model type emerged in my research process around the time of the second phase of interviews in 2005, as a product of the combined influence of the international literature on new CoEs and NoEs, and the provisional findings of my case studies. I was influenced particularly by leading international researchers like Van der Meulen and Rip, who had undertaken an intensive but wide-ranging study of a sample of what they termed
CoEs across Europe and Australia, and came to the conclusion that some of the major attributes of a ‘well-founded institute’ or CoE were the following:\textsuperscript{59}

Strong director with a vision, respected by the staff; size between 50 and over 100 staff; good-quality research with international scientific reputation as a resource; hierarchical organisation and strong elements of consent; protected by an advisory board of governors; adhocracy so can adjust; well endowed with providers and sponsors; use of PhDs and young scientists as key resource; rewards for variety of research products and services delivered; internal composition of four or five research groups/teams each with six to eight researchers. (My summary of key features provided by Van der Meulen & Rip 1994: 61–65)

Important in this list of attributes, when related to Figure 3.3, is their stress on the following:

- a research director (‘strong’ and with ‘vision’);
- a hierarchical organisation with four or five research subgroups (with ‘PhDs and young scientists as key resource’ within each subgroup); and
- use-oriented research (‘research products and services delivered’, linked to funders as ‘providers and sponsors’), based in effect on at least some quality UIBR (‘good-quality research with international scientific reputation’).

Perhaps the only difference between their (mainly European) conception of such an institute/centre and the situation in South Africa is that the centre type proposed by them is nearly twice as large (up to 100 or more staff) as a similar one in the Western Cape – itself reflecting the under-resourcing of the South African centres (see Part 2).

I was also influenced significantly in conceptualising the idea of this Model A type by Bozeman and Boardman’s definition of MMURCs (cited earlier in this chapter), which, like my definition, stresses the following features:

- a centre that is organisationally separate from an academic department; and
- a use-oriented research mission linked to external partners.

Again, my own definition in Figure 3.3 is very close to this, with only their stress on multidisciplinarity as a requirement not included here.\textsuperscript{60}

It is important to stress that a number of other significant features are embedded within this construct of a Model A centre type. Firstly, it is hypothesised that a crucial layer of personnel within Model A consists of the senior researchers, who are not to be conceived of as post-docs but as mid-career senior researchers (with preferably at least 5–10 years of research experience), who each lead their own subgroups (of postgraduates and post-docs in Figure 3.3) in the research sub-programmes of the centre. Moreover, as will be explored in the case studies, it is hypothesised that such ‘seniors’ are increasingly developing a career track as ‘researchers.’ That is to say, they are developing a self-identity that is different from the ‘researcher-lecturer’ identity of the traditional professors as PIs leading Model T unit types within academic
departments. Thus it is proposed that such seniors are part of a new second academic transformation, with a new identity type.

Secondly, it is important to note (see Figure 3.3) that the size and complexity of a Model A centre type seems to require a further layer of what I term the ‘centre administrative and technical infrastructure’, comprising a sizeable number of personnel to undertake such tasks linked to the exigencies of use-oriented research.

Thirdly, it is vital to recognise that the Model A centre type is ‘organisationally separate from an academic department’ (Bozeman and Boardman’s definition), by which is meant that in regard to its research mission and research funding it has control and autonomy separate from an academic department. It follows from this that such a centre almost invariably has its own specific research name, making it what I term in Figure 3.3 a real centre, with official recognition and designation within its university.

Finally, and perhaps most important of all, is the proposition that the seniors – as noted, each heading a subgroup with its own sub-programme of research – nonetheless fall under the collective control of the centre as a whole. They are therefore accountable specifically to the professor-director leading the centre’s research programme and mission, and also usually to an advisory board at the apex of control. Thus, with reference to Etzkowitz’s work on emergent centres at MIT/Stanford cited earlier in this chapter, it is hypothesised that a Model A centre type has a degree of ‘collectivity’ – unlike the individual professor-PI of Model T (and Model B), who heads his/her own small, autonomous research unit. It follows that the senior researchers heading the subgroups in Model A cannot simply do their own thing, but are accountable in important ways to the centre director as head of the research mission. This hypothesis of reduced research autonomy for these seniors of a Model A centre type will be investigated across a variety of centre types in the Western Cape case studies that follow, and compared to the autonomy of an individual professor-PI of Model T (as exemplified by Case 0 in Part 2).

Model C: A new virtual centre type

The literature on NoEs and their variations – including the American ERCs and SRCs, which often functioned as networks joining up previously stand-alone research centres and units of different universities – influenced the concept of a Model C virtual centre type presented in Figure 3.4. So did my preliminary findings after the second phase of interviews in 2005, when a ‘network of professors’ mode began to surface in some of the cases. It should also be noted that this specific model type, for the purposes of analysis of the use-oriented Western Cape cases (focusing initially on Case 3, and later on Cases 8, 9 and 10), was defined as a research network based only (or almost entirely) at one university. This was because the sampling method employed at the outset in 2000 for the selection of these research groupings specified that they be based at one university (or primarily at one; see Appendix 1).
Figure 3.4 A network of PI-units (research subgroups): A new ‘virtual’ structure combining features of both a small unit and a large centre

Essentially this model type comprises a network of professors who come together under the umbrella of a common research programme, usually for a defined period of time. It is thus generally not a permanent structure, at least not in terms of its initial conception. Usually, too, the professors each retain a base in their home departments. In terms of this hypothesis, each professor-PI still has broad control over her/his own subgroup of postgraduates and a few post-docs, often utilising partly their own research funds and partly the collective funds made available...
for the network as a whole. One professor usually serves as coordinator or even director for the whole network – but with less authority over the whole research programme than in the ‘real’ and formally constituted Model A. It is my argument that in some respects this use-oriented Model C network or ‘virtual structure’ lies in between Model B on the one hand, with its high level of autonomy for the professor-PI who heads the small unit, and Model A on the other, with its relatively lower autonomy for each senior researcher under a strong centre director with a clearly defined third mission.

In fact, I suggest that this *in between* status gives the Model C network centre type an attraction for professors whose academic careers have usually been based in a departmentally rooted, traditional Model T type. Such professors may thus avoid a full jump into a second academic transformation structure like a Model A real centre; instead, they retain relative autonomy, but also draw on some collective funds and certain other collective forms of administrative and technical support within such a network system. I also hypothesise that, like the professor-PI of a Model B small unit under pressure from its third mission, they do begin to shed some undergraduate teaching as well, depending on the context (i.e. this occurs in an ad hoc way, without clear norms and rules, thereby contributing to some of the ‘creativity and chaos’ of such a virtual structure).

Having set out these model types and their associated hypotheses, I now turn to a more empirical focus on the internal organisational forms of the 11 case studies presented in Part 2, and the dynamics and forces shaping them.

**Notes**

1 See also Perez (2002) for her focus on approximately 50-year waves, which I feel are valuable (and which Dicken refers to in his analysis), although they do not incorporate socio-political contextual factors. Hence my preference for the ‘very long’ 100-year periodisation of Table 3.1. The ‘capitalist forms of economic organisation’ for each revolution are drawn from various Marxist sociology texts.

2 As noted in the Introduction to Part 1, the focus on major technologies as one important independent variable is derived from a traditional Marxist stress on the ‘forces of production’ (see for example Cohen 1978), which I believe is still valid. However, I have preferred the term ‘technological regime’ drawn from Rosenberg (2000), although I use this slightly differently, applying it to ‘long waves’ of 100 years, which I believe can be conceptualised under a common ‘regime’ of technology in Rosenberg’s sense.

3 This also applied to later key technologies such as automobile and aircraft technology. For example, in describing aeronautical engineering in the 1920s at Stanford University, Mowery et al. note that ‘Extensive experimental [parameter variation] testing was necessary because of the absence of a body of scientific knowledge that would permit a more direct determination of the optimum design of a propeller in an aircraft’ (2004: 16).

4 As defined by Etzkowitz (2002), whereby basic research (the second mission) was added to teaching (the first mission). See also Chapter 2 for discussion of the rise of the elite group of American ‘research universities’ with their ‘first academic transformation’ during the last
quarter of the nineteenth century, though their professional training role (in engineering, natural and health sciences, commerce, etc.) was initially (at least up to the Second World War) considerably more important for industrial development than their research role.

5 The varied internal organisational structures of TNCs and their diverse external networks of firm 'clients' cannot be explored here, but for elaboration of this see Dicken (2003: 238–273).

6 It is not necessary for one to accept the ILRIG explanation of this economic slowdown/crisis in terms of what they call the (primary) problems of over-production and over-consumption (ILRIG 1998: 12; also Brenner 2006). Instead, it can be argued that from the late 1960s other important factors also played a role. These included the Vietnam War, competition from Europe and Japan faced by American-based capital, the organisational strength of European trade unions (blocking production flexibility on the shop floor) and, not least perhaps, a generalised spread of similar technological levels by the 1960s across firms in the advanced industrial countries, making it difficult to realise ‘super-profits’ through standard technological innovations. (A lift-off to a new and significantly higher technological level was therefore needed after the 1970s to raise profitability for the most innovative firms.) A group of important factors thus came together after the late 1960s – not only the (often cited) immediate factor of the oil crisis of 1973 – and these all contributed to the central issue being considered here: a generalised global economic slowdown rooted in problems at a deep level of production and profitability.

7 Dicken (2003: 221–228) argues convincingly that even at the turn of the twenty-first century, TNCs were in many fundamental ways still 'national'. For example, in financial, organisational and even internal cultural forms, General Electric, historically rooted in the USA, is still significantly 'American', Hitachi is still 'Japanese', and Siemens is still 'German'. For this reason, the organisational form 'truly transnational' has been qualified as 'truly?' in Table 3.1.

8 Other important factors that have facilitated the leadership role of the USA in the third industrial revolution include its international political hegemony, and the organisational form of its TNCs (on the latter, see Dicken 2003: 198–221). Here, however, only the crucial role of the American university system in relation especially to PBR and UIBR will be considered.

9 Their important article is aptly titled 'The American Research University System as America's de facto Technology Policy' (Crow & Tucker 2001).

10 Note, especially after the launch of the Russian sputnik in 1957, how the Sputnik was taken as a challenge to American science, and a strong basic science base was now argued for as being central to military security – leading in the decade after Sputnik to an almost fivefold increase in federal funding for what was viewed as 'basic science' (Stokes 1997: 55).

11 I further suggest that the development of a high-quality PhD system of 'coursework plus thesis' at American universities after the 1870s, which expanded dramatically after 1945, provided another important building block for the construction of this basic research foundation in the USA (see Cooper 2006).

12 See Geiger (1993) for a full examination of the period from after 1945 until the late 1980s, as well as his more recent work (2004: 134–139) for an outline of his core arguments and data up to 2000. Below I refer mainly to Geiger (1990) as summary of his data for the period covering the 1970s and 1980s.
Geiger's data thus support my earlier point that the global economic slowdown in the early 1970s actually pre-dated the 1973 oil crisis, and was therefore shaped significantly by deep factors linked to capitalist production.

Geiger (1992: 11, Table 1.3) gives a figure of 63 per cent in 1960 for the percentage of federal government funding of total university R&D.

For private industry support of university R&D, Geiger (1992: 14) in another article provides a figure of 1.4 per cent for the late 1960s and 6.6 per cent for 1989. But he argues that the latter was closer to 10 per cent (which was roughly double what it had been 15 years earlier) because of indirect funding, such as industry-related foundation funding and private contracts with academics.

See the previous footnote for Geiger's slightly higher estimates, but note that these authors agree on an industry figure of still only around one-tenth, or less, of all university R&D. This corresponds, too, with Bozeman and Gaughan (2007: 694), who provide a figure for 2002 of 6.8 per cent for American industry as a proportion of all American academic R&D through formal I-U research agreements. They note, however, that this percentage excludes direct funding of academics who sign individual contracting agreements with companies.

Their data exclude FFRDCs (Mowery et al. 2004: 23, Table 2.1). Note that the figures in their table correspond closely to Geiger's (2004: 136) in his more recent study, which shows a fall of federal government support for academic R&D from 67 per cent to 58 per cent over the period 1980–2000, with a concomitant rise of industry funding from 4 per cent to 8 per cent.

This point of 'basic-applied combined' is noted too by Mowery et al. (2004: 26) with respect to research funded by the NIH, Department of Defense, Department of Education, NASA, etc. They cite also with approval Stokes's idea of Pasteur's Quadrant.

For a useful, broad review of a range of perspectives of the 'new knowledge production,' especially in relation to Mode 1/Mode 2 debates around ideas of Gibbon et al. (discussed later in this section), see Hessels and Van Lente (2008).

For example, in his chapter 'The Historical Evolution of the Triple Helix,' Leydesdorff (2006: 210) mentions that, after the oil crises of the early 1970s and 'proposals for reindustrialisation' from the late 1970s, a 'more proactive science, technology, and innovation policy' began to be developed, incorporating different connections between state, industry and academia (i.e. the triple helix). But he does not explore in any theoretical depth the possibility of a new historical moment in the late 1970s with respect to the capitalist industrial system and universities.

See the useful summary of the ideas of their 1994 book and their work that followed (Nowotny et al. 2001), provided by Nowotny et al. (2003) as part of a special edition of the journal Minerva on Mode 1/Mode 2 debates.

Although such a crude pure/applied dichotomy was not intended by their Mode 1/Mode 2 framework, numerous South African academics did interpret it this way – see Kraak (2000).

See also, for example, Burawoy's (2010) analysis of SWOP (the Sociology of Work Project), based in the Sociology Department at the University of the Witwatersrand, and my own analysis (Cooper 2009a) of ILRIG, based in the Sociology Department at UCT. For works on broader civic linkages beyond the labour movement, dealing with U–CS research relations during the three decades since the 1970s, see, for example, Hofmanner's (2000) case study.
See also the websites of the various international triple helix conferences (e.g. www.triplehelix4.com and www.triplehelix5.com) over the past years, which reveal very few works specifically focused on U-CS research relationships, while U-I, U-G and I-G relationships are covered in hundreds of papers, including keynote presentations.

The first Triple Helix Conference of U-I-G relations was held in 1996 in Amsterdam, followed by New York (1998), Rio de Janeiro (2000) and Copenhagen (2002). Further conferences have been held approximately every two years thereafter.

This is also a major concern of the influential 2001 book by Nowotny et al.

See, for example, the website of the National Collaboration for the Study of University Engagement of Michigan State University, which has played a leading role in the development of ideas and practices in relation to what it now terms 'engaged scholarship'. The latter concept, which stresses reciprocal relationships between university researcher and community, has evolved from its earlier concept of 'public service and outreach' (see Cooper 2009b for further discussion).

Renamed in 2001 the Journal of Outreach and Engagement.

The AASCU (2002: 9) defines 'public engagement' as follows: 'The publicly-engaged institution is fully committed to direct, two-way interaction with communities and other external constituencies through the development, exchange, and application of knowledge, information, and expertise for mutual benefit.'

See McMillan (2009: 40) for a definition of 'student-service learning'.

The fund was set up in 1975 to stimulate economic development in the least prosperous regions of the EU.

See, for example, the recent collections of case studies – or 'portraits of practice' – compiled annually for each of the years 2005–09 by the UCT Social Responsiveness Working Group. These portraits document research and other scholarly work undertaken by academics and research groups at UCT, mainly for civil society groupings (UCT 2005–09; see also Favish & Ngcelwane 2009).

For Latin America, see for example Arocena and Sutz (2001).

I have added the term 'local' here, since what is being referred to is the sub-national level of local regions (such as the Western Cape) and not the equally important supranational level of large new regions (such as the EU).

Current data for South African unemployment, based on the 'official' definition of the International Labour Organisation in terms of the question 'have you looked for work in the previous month', generally yield a percentage below 30 per cent – but how many of our unemployed did actively 'look for work' in the last month?

Numerous definitions are available of these two concepts. The sources provided here are selected because their perspectives are among the currently most well developed.

Student 'service-learning' is regarded as part of social responsiveness by the UCT policy document, but cannot be explored here.

In fact, when the Social Responsiveness Working Group at UCT undertook the collection of 'portraits of practices' (see University of Cape Town 2005–09), some of the university groups that were undertaking research for industry organisations or national government argued precisely this with respect to their use-oriented research activities.
In terms of my analysis in the first part of this chapter, such industries focused on steel, automobiles, electronics and aircraft were all of the 1960s/70s 'last phase' of the second capitalist industrial revolution. My argument is therefore that the USA needed a significant 'gear shift' into a new third industrial revolution, to achieve higher competitiveness from the late 1980s onwards.

Square brackets are my additions; round brackets are inserted by Bozeman and Boardman.

Again, square brackets are mine for clarification, from data derived elsewhere in the interview analysis of Bloch by Bozeman and Boardman.

By 1999 it was estimated that 13 per cent of NSF funding for research activities was going to 196 university-based research centres, which included 18 ERCs, 23 STCs, 52 federal IUCRCs, 6 state IUCRCs, 10 centres of research excellence in science and technology, and a range of other types of 'special' centres, for example earthquake engineering research centres, plant genome virtual centres, an institute for theoretical physics, etc. (Malkamaki et al. 2001: 84, 86–89).

By 2004 there had been 56 ERC awards from the NSF over a series of cycles of competitive awards, but the centres were each expected to become self-sufficient after an extended cycle of 11-year funding – with some surviving and others not (Bozeman & Boardman 2004: 368).

By this definition it also seems that a URC could be formally located within a department as long as it was 'set apart from the departmental organisation'; that is, was relatively autonomous from the department in organisational and line management terms.

As mentioned in Chapter 1, their data showed an average of 14 participants per project for FP6, rising from an average of seven for FP5.

Data for the 17 country case studies were collected in 2001 by Academy of Finland researchers from CoE publications and brochures, web pages and via emails and phone calls to the respective research funding organisations (Malkamaki et al. 2001: 7). For some of the cases cited below, I provide additional information from one or two other sources.

'Small' here for the Finnish programme should also be read in relation to the form of 'institutes' in some European countries, which have been historically considerably larger than 50 personnel (see Van der Meulen & Rip 1994, and the French CNRS and German Max Planck Institutes noted below).

The influence of the Canadian model of research chairs on SARChI was directly acknowledged in a presentation by Professor Tessa Marcus at the South Africa–Canada Research Chairs Colloquium hosted by the South African Association of Canada Studies in Cape Town in February 2008, which I attended. Marcus was leader of the SARChI initiative at the NRF when this programme was developed and launched during the period 2004–06.

Note that many of the USA STCs/ERCs were multi-university (Bozeman & Boardman 2004), while the South Korean university-based CoEs had strong collaborative links with research groups in industrial and government organisations (Ahn 1995).

Van der Meulen and Rip (1994: 17) have pointed out that similar developments took place elsewhere in Europe during the post-war period – for example, the Consiglio Nazionale delle Ricerche in Italy, and the Consejo Superior de Investigaciones Científicas in Spain.

Humboldt's reforms were based significantly on his concept of the integration of teaching and research, rooted also in the idea of 'new knowledge' or Wissenschaft.
In the previous chapters I also referred to this as PBR or ‘curiosity-oriented’ research.

Turner (1975: 531) suggests a date of around 1835, by which time the ‘modern’ system of specialist disciplinary fields of the ‘research of discovery’ had significantly taken root.

By the 1920s there had been a limited expansion of ad hoc (pre-Habilitation) contract research assistants, who became, in effect, post-docs under an emergent system of fixed contract salaries. The Privatdozenten, who had already obtained their Habilitation but did not yet have a chair, became de facto those assisting the chair in teaching and research (Busch 1962: 335; Enders 2000: 26–31).

The system of post-docs emerged significantly only after the First World War (Assmus 1993), since before this time most PhD graduates wishing to pursue an academic career immediately entered vacant positions across the universities of the USA.


‘Organised research units’ is the term historically used in the USA (see Friedman & Friedman 1984).

In this specific sense, therefore, the term ‘traditional’ in this book is always used with reference to this first academic transformation of the mid-1800s to the mid-1900s.

The study of research groupings by Van der Meulen and Rip (1994), involving case studies of CoEs across Finland, Germany, the UK and Australia, excluded what they called ‘research networks’ or what I have referred to as NoEs. What they refer to as ‘research institute’ or ‘centre for excellence’ seems close to what I have called a ‘real research centre’, as can be seen from their list of attributes reproduced here.

Although empirically I suggest later that almost all the Western Cape cases did fulfil the requirements of multi- or inter-disciplinarity, my definition of the Model A type in Figure 3.3 does not exclude the possibility of such a centre being based only in one traditional discipline, for example chemistry. It also does not exclude such a Model A centre being located in only one department, even though this might be unusual. Similarly, while the majority of MMURCs investigated by Bozeman and Boardman at American universities were multi-institutional, my own definition based on the Western Cape experience does not stress a multi-university base.

Thus, with reference to the previous footnote, it is possible – though not usual – for such a Model A centre to be physically located within an academic department, as long as the line management (via centre director and often centre advisory board) has autonomous control over its research mission and funding. Such a departmentally based ‘centre as collective structure’ would thus be similar to the usual small PI units of research found within a department, which in effect also all retain research autonomy from their department, as previously noted.

As already noted, the Canadian type of NCE, which specifies networks of professors across different universities, only began in 2004 and was taken up in policy across a few South African universities, via the NRF funding of what were called CoEs (see the Introduction to Part 2). This occurred too late to influence my sampling for the Western Cape research groupings (see Appendix 1). It should be added that in 2000 the idea of virtual centre-type networks spanning universities in the Western Cape had not been widely adopted. Hardly any such NCEs existed there at that time, or by the time I conducted the third phase of interviews in 2007.
Case studies at the universities in the Western Cape
Introduction: A short overview of South African research and innovation

This introduction begins with a brief historical and contemporary sketch of some relevant features of South African research and innovation systems. It then provides a quantitative analysis based on various salient R&D indicators. Wherever possible, international comparisons are made in relation to these South African indicators. The aim is to tell a story about the unfolding of certain pertinent aspects of research and innovation in this country, in order to contextualise the 11 Western Cape case studies that are examined in detail in the two chapters that follow.

The evolving systems of research and innovation in South Africa

The pre-1994 context: A brief historical overview

In South Africa perhaps the first research-oriented organisations were the South African Museum and South African College (established in 1823 and 1829 respectively). For the half-century after the 1820s, the main focus areas of scientific investigation were southern flora and fauna, and the heavens. In 1867 this quasi-rural idyll was shattered by the discovery of the Kimberley diamond fields, which laid the basis for the capitalist industrialisation of South Africa, and the institutionalisation of what came to be known as ‘baasskap’ and later as ‘apartheid’. Next followed the discovery of the Witwatersrand reefs, whose metallurgy demanded constant technological innovation that led to the emergence of linkages between UCT, the College of Mines (which later evolved into the University of the Witwatersrand) and industry. And, for example, managing the health of miners under the extreme conditions of deep mining and poor living conditions in turn demanded specialist research, so that in 1912 the Chamber of Mines and the Union Government established the South African Institute for Medical Research.

The interwar period saw the expansion of the university system rooted in ‘white’ institutions (see below), the founding of national industries for power, iron and steel and communications, and the diversification of the industrial base as a developmental state assumed form. The seminal role that scientific research played internationally during the Second World War (see Chapter 2) persuaded the Smuts government to further strengthen the South African state’s hand in R&D through the founding in 1946 of the Council for Scientific and Industrial Research (CSIR). Thus by the end of this war, South Africa was already moving along the path of
constructing research structures with foundations in a set of university- and non-university-based institutions, all with significant links to industry – that is, there was already an embryonic triple helix in the making.

The 1948 election of the white supremacist National Party government marked a turning point in the nature of the research and innovation systems, which now became more directly aligned with the mission of preserving white power. As the perceived need for self-sufficiency in a hostile world (a self-fulfilling prophecy) grew, so did the technological response of orienting research towards industrial and military innovation. Thus, as argued by Kaplan (1996), armaments and atomic energy, supplemented by oil from coal and later, to a lesser extent, by telecommunications, became the bedrock of a ‘strategic’ national R&D system.

The intensification of apartheid under the fiction of ‘separate development’ and the deepening of internal conflict led to the gradual imposition by the international community of an arms embargo, and the role of some research institutions such as the CSIR taking on elements of a state weapons laboratory. One the one hand, hopes that South Africa would catch up with other advanced economies were dashed, as the country entered a period of low growth and eventual decline as a result of financial sanctions and other forces imposed on it.

On the other hand, one might argue that the relatively small South African research and innovation systems, driven by the ‘constructed crisis’ (Kahn 2006) of apartheid, were also relatively successful in that they produced certain components of world-class science in fields such as catalysis, clinical medicine, plant and animal sciences, mining engineering, metallurgy and entomology – laying the basis for the future careers of four Nobel laureates in the sciences. Thus, unusually for many Third World countries at the time, South Africa was evolving capacities for high-quality UIBR in some (albeit limited) areas.

The higher education system itself was balkanised to provide the necessary (white) high-level scientific and administrative skills for the state and business on the one hand and, on the other, civil servant (African) personnel for the so-called bantustans on the periphery. Here, already by the early 1980s, a segregated system had thus been consolidated, with 10 white universities (and sometimes also the distance-learning university Unisa) performing the first function, while six African universities had been created on the rural periphery to fulfil the second function.4 In addition, arising out of the historically white technical college system, a group of white post-matriculation technikons (initially called Colleges of Advanced Technical Education) emerged in the major urban areas in the 1960s/70s. And, given apartheid ideology, these seven white technikons (plus one distance-learning technikon) were complemented by five African technikons, and an Indian and coloured technikon respectively (see Cooper & Subotzky 2001: Chapter 1).

How the five HEIs of the Western Cape – two elite white universities, one historically coloured university, one historically white technikon, and one coloured technikon –
fitted into this structure of 21 universities plus 15 technikons in 2000 (when this study began) will be outlined at the end of this Introduction.

In February 1990, the National Party lifted the proscriptions on a range of outlawed organisations, opening up the space for democratic political activity. Alongside intense political contestation, some other state activities continued unrestricted, including the transformation of many state laboratories into ‘agencies’ through ‘framework autonomy’, and the creation of the Agricultural Research Council in 1990 and the Council for Geosciences in 1992. What was viewed as a privatisation agenda was further pursued, for example with the incorporation of various weapons facilities into Denel, a new state-owned enterprise (SoE). By this stage, too, the set of state-run science councils had expanded to eight, making for a significant research base outside the universities – with this ‘parastatal’ grouping significantly oriented towards PAR rather than UIBR (see for example the Case 1 analysis in Chapter 4, with reference to a specific agri-sector).

A public science policy debate under the ANC-aligned Mass Democratic Movement (MDM) emerged alongside these National Party-led state initiatives. This led to the tabling of a first S&T policy document at the ANC National Policy Conference of December 1992. Next followed the MDM-brokered review of the national science system (IDRC 1993), which concluded that this system was dysfunctional, highly fragmented and racially skewed, and that it did not serve the majority of South Africans, lacked coordination and was constrained by what it termed ‘frozen resource allocation’.

Towards a ‘knowledge-based economy’: 1994 and beyond

The new democratic government of 1994 established a Department of Arts, Culture, Science and Technology (DACST), whose agenda of change gave rise to a widely canvassed White Paper (DACST 1996). This policy document explicitly introduced the concept of an NSI and sought the means to ensure cohesion and demonstrate measurable outputs. It recognised the importance of what it viewed as ‘knowledge-based’ transformation being nurtured by the unfolding ICT revolution; it also recognised that in order to prosper, South Africa would have to compete in the global market. Specifically, it argued that:

[t]he promotion of a national system of innovation as a framework for social and economic policy maximises the possibilities for all parts of the system to interact with each other to the benefit of individual stakeholders or groupings of stakeholders and the advancement of national goals... [and would] stimulate [such] collaborative, multidisciplinary, applications-based research. (DACST 1996: 10)

Here we see clearly a stress on use-oriented research within a cohesive and integrated NSI. Further, such an NSI focus was oriented towards industry and government as sources of technology transfer – civil society was not seriously considered, nor
did the social sciences feature strongly. However, knowledge and human resources development in science, engineering and technology fields, it was argued, would ‘...enhance the rate and quality of technology transfer and diffusion from the science, engineering and technology (SET) sector by the provision of quality human resources, effective hard technology transfer mechanisms and the creation of more effective and efficient users of technology in the business and governmental sector’ (DACST 1996: 13).

Articulated in this way, the NSI is given almost living form as a force to demonstrate a break with the past, for the public good (a broader ‘public’ than under apartheid), albeit within a quite typical framework of the triple helix focused on (natural) science and engineering:

Thus, a national system of innovation can only be judged as healthy if the knowledge, technologies, products and processes produced by the national system of science, engineering and technology have been converted into increased wealth, by industry and business, and into an improved quality of life for all members of society. (DACST 1996: 19)

The White Paper furthermore argued for the inception of a culture of performance measurement, the introduction of a mechanism for competitive R&D funding, and the establishment of a new high-level body to advise government on matters of S&T. These recommendations were to be realised some years later, for example in the institutionalisation of S&T indicator production in the Human Sciences Research Council (HSRC), the creation of the Innovation Fund, and the founding of the National Advisory Council on Innovation, respectively. DACST, like its predecessor the now disestablished Department of National Education, retained responsibility for allocating the parliamentary Science Vote to the eight science councils, via the National Advisory Council which became the means for deciding on the slicing of the budget pie among them. The new Innovation Fund was given the biggest allocation of budgeted funds. Yet the bulk of state funding for higher education research came from the Education Vote of the new Department of Education (DoE). Thus the DoE potentially retained a crucial controlling influence on a major element of the NSI: university research by academic staff. Some implications of this will be explored in Part 3 of this study, following detailed investigation of research centre/unit funding with regard to academic research careers within the case study material of Part 2.

It should be noted that DACST in 1995 tasked the Foundation for Research Development with conducting the National Research and Technology Audit, one of whose deliverables was to be an online R&D output and infrastructure database. Some important reports were produced, but the database did not materialise. A second intramural initiative informing policy was the National Research and Technology Foresight study of 1996–99, which also produced reports after which the foresight process appeared to terminate. In a parallel process running over 1997/98, the science councils and a number of department-based research institutes were subject to the Science, Engineering and Technology Institutions Review. These
reviews accelerated the push for the science councils to host a demographically representative workforce, but there is little evidence of a major shift in their science agenda at this time. All this suggested that some of the initiatives for a new NSI were strong in vision, but much weaker with regard to new modes of implementation.

Another policy initiative which occurred in 2001 did, however, bear more fruit: the Biotechnology Strategy leading to the establishment of the Biotechnology Regional Innovation Centres (BRICs). The four BRICs might be understood as quasi-venture capital entities which provide grants in their own specific areas of interest, and whose grants are subject to the sharing of equity and intellectual property. Some impacts of one such BRIC will be considered when the material of Case 1 is examined later.

As to the universities and technikons, the major producers of basic research within the system, these were subject to a process of mergers, and in rare cases closures. This saw them reduced to 23 in number by 2006, comprising 15 universities, six universities of technology and two comprehensive institutions. The merger process was conflict-ridden and complex (Jansen 2003) with some instability persisting up to the present. But it was largely business as usual for most of the ‘Big Five’ institutions comprising the more research-intensive HEIs, namely the universities of Cape Town, Pretoria, Stellenbosch and the Witwatersrand, as well as the University of Natal (English, white), which merged with the University of Durban-Westville (Indian) to become the University of KwaZulu-Natal (see below). In 2004 a revised funding formula for higher education came into effect. This formula includes a research output component that recognises the production of master’s and doctoral students and research publications. The so-called publication subsidy now amounts to in the order of R1 billion, which goes directly to the central funds of the universities, with a proportion of this subsidy making its way to the research accounts of faculties/ departments and sometimes academic staff. The journal subsidy amount involved is around four times that which flows as directed funding to the universities from the NRF. There is speculation that the journal subsidy (which in 2008 was about R105 000 per publication) is influencing behaviour with regard to publication tactics (Mouton et al. 2006), including – as will be considered in some case studies – acting as an inhibitor of other forms of knowledge transfer, for example policy reports to government, industry and civil society organisations.

The end of political isolation liberated business and industry to pursue their local and global interests, and prosper accordingly, within a largely neoliberal framework regulated by the practices of the International Labour Organisation and the World Trade Organisation, and a set of national labour laws which aimed at greater equality and redress. Just over a decade after 1994, the economy, with low inflation and moderate growth, was in better shape than it had been for some 40 years. Restrictions on foreign investment by South African firms were eased, with special preference given to the African continent. South African corporations marched across the Limpopo River, establishing themselves among leading TNCs active in mining, telecommunications, pulp and paper, agro-processing and brewing, retail, financial services, logistics and leisure. Given this clear expansion and consolidation
of South African industry by the time of the interviews for this study (2000–07), the centrality of industry for university research – that is, within the triple helix of U—I–G relations – will be a focal point of investigation across the 11 case studies.

It should be noted, too, that in 2002 the National Research and Development Strategy (DST 2002) emerged as the first product of the DST which, now stand-alone, consequently had a more streamlined focus on R&D, including innovation. The R&D Strategy pivoted on the claim that the ‘…termination of key technology missions (such as military dominance in the subcontinent and energy self-sufficiency) by the previous government between 1990 and 1994…resulted in a drop in national R&D spending from 1,1% in 1990 to 0,7% of Gross Domestic Product (GDP) in 1994’ (DST 2002: 15). There was also a concern that the private sector was reducing its investment in R&D. No empirical evidence was afforded to support these claims. The scaling down in military R&D had commenced in 1988 before the claimed slowdown; and the available evidence of the R&D survey time series (Kahn & Blankley 2006) showed that private sector investment had picked up from its 1987 low point throughout the 1990s. There is no disputing the R&D Strategy argument, however, that coordination of R&D remained elusive.

This 2002 R&D Strategy instrument proposed five new ‘technology missions’ of biotechnology, information technology, technology for advanced manufacturing, technology for and from natural resource sectors, and technology for poverty reduction. The intention was to provide a focus for national R&D efforts, much as the previous strategic missions for energy and weapons self-sufficiency had done. Some of these new missions had impacts on the work of the research groupings considered in the case studies to follow, and are noted where relevant.

The R&D Strategy sought to ramp up the human resources stock and enhance coordination of the NSI, and included a mandate for coordination of R&D across government. A new agency was set up – the Technology Innovation Agency, which came into being eventually in 2009 – to promote innovation ‘from concept to market’, and the target of doubling nominal R&D investment in the public sector was attained in just over four years. But the goal of steering the direction of R&D remained largely elusive.

It is also important to note the disparity between the size of funding initiatives under direct DACST/DST control and the budget resources embedded in the parliamentary Science and Education Votes, which are both characterised by the logic of incremental budgeting year-on-year. The direct funds largely comprise the Innovation Fund and BRICs funds, and totalled about R300 million in 2002, whereas the Science and Education Votes contributions were in the order of R2.1 billion in that year (DST 2004: 6). The DST could thus hardly be expected to exert major influence on the research agendas of the arms-length statutory science councils and the autonomous universities. For the universities themselves, the DoE (and since 2009 the Department of Higher Education and Training) has continued to be the crucial outside influence on academic research, with publication support coming
from this source, not the DST. Moreover, patent activity had become very much a business matter and was no longer a significant aspect of the activities of ARMSCOR (Armaments Corporation of South Africa, now largely reconfigured as the privatised entity Denel) or the CSIR, both of which had been important patent filers in the 1980s and 1990s.

What the DST could do was to designate funding for a given area (e.g. BRICs) and then wait for research proposals. It was also able to promote the Square Kilometre Array telescope, and in 2006 launched the relatively well-endowed SARChI (see next section), which is arguably the most important injection of funding into high-level human resource development and research for a generation. The back room influence of DST on other policy initiatives is unknown. Two other important DST policy instruments were the inception in 2007 of an enhanced tax incentive for business sector R&D, and the regularisation of the ownership and disposal of IP arising from publicly funded R&D. These various instruments certainly did make for symbolic congruence between South African innovation policy and that of the OECD, with regard to its ideas about NSIs (see Part 1). Some major contemporary instruments are thus in place, and some are at the leading edge, for example those concerned with the protection of biodiversity and indigenous knowledge systems. But the congruence is described as symbolic because it is the operationalisation of government policy that matters more than its form.

Interestingly, too, in terms of international comparisons the flow of funds from industry to higher education is high (see the data on business expenditure on R&D in Table ii.2), yet there is a very low level of scientific co-publication. Indeed, South African industry showed more diverse scientific publication 15 years ago than it does today (Kahn 2010). And while the Technology and Human Resources for Industry Programme (THRIP, see below) is an exemplar of constructive links between industry and higher education, both HEIs and industry have a very low rate of patent filings.

This, then, is some of the background to the tabling of the 2008 Ten Year Innovation Plan (DST 2008) with its five Grand Challenges: ‘Farmer to Pharma’; Space Science and Technology; Energy Security; Global Change, especially climatic; and Human and Social Dynamics. In many ways these five, along with accompanying indicators and targets, are a continuation of the five technology missions of the 2002 R&D Strategy. In fact, the earlier fifth mission of this Strategy of ‘technology for poverty reduction’ was always much vaguer and more difficult to operationalise than the other four, with their clear S&T foci. It appears that the fifth of these new challenges, Human and Social Dynamics, once again is less clear than the other four. This highlights the fact that some of the weakest areas of thinking about the research and innovation systems are around issues of poverty and marginalised groups outside of the formal economy – a situation readily recognisable in terms of the ‘absent (U–CS) fourth helix’ concept discussed in Part 1.

As published, the 2008 Innovation Plan reads more as a vision statement than a plan, in that it does not go into the detail of delivery mechanisms, budgets, timelines
and responsibilities, even for the other four challenges. It is bold in advocating targets that will entail a considerable stretch, but at least one target appears to be unattainable. This is the goal to raise annual production of SET PhDs to 3 000 from the 2005 level (including foreign students) of 561 (DST 2008: 8). An increase of such scale can only occur with an exceptionally determined injection of resources, and this has not happened as yet (but see further discussion in Part 3). The intended dramatic expansion of research and innovation is laudable, but who will do the research work? Where will the additional PhD supervisors come from? Through its declared alignment with the R&D Strategy, the Innovation Plan maintains the general direction of the system. It does not yet appear to be a strong agent of change.

A key political question is the extent to which the pre-1994 systems of research and innovation have been transformed to better serve society post-1994. This brief overview cannot provide a definitive answer to such a complex question. Such systems build competence and direction over long periods; it is easy to terminate programmes (i.e. to close the financial tap), but harder to launch new ones, especially where finances are small and societal demands for restitution are great. Seen through the lens of scientific publication, these systems have shifted emphasis slightly (Kahn 2010) – for example with the rise in importance of what might be termed the infectious diseases cluster of disciplines, while a reduction in the procurement of military equipment from local suppliers has undoubtedly led to a decrease in the proportion of R&D expenditure going towards defence-related work. But there are absent discourses, for example relating to how the reconstructed systems will successfully affect the livelihoods of the poor, who generally live outside the formal economy and the reaches of triple helix research relations. Also absent are discourses about how research centres and units within universities pursue their own research missions, often fairly independently of the various national government ‘initiatives from above’ – an issue which will be central to some of the analyses of the case study material which follow.

This section concludes with a brief summary of certain specific initiatives undertaken since the 1990s (some already discussed), which serves as a reference point for their citation in the 11 cases investigated in Chapters 4 and 5.

Government-funded R&D support incentives

**THRIP:** Established in 1991, the programme is a joint initiative between industry, research and HEIs, and government. The programme, administered by the NRF, supports the development of technology for industry (with a focus on bringing research findings to the market) and of human resource development for industry (with a focus on training of master’s and doctoral students). Support from the Department of Trade and Industry grew from less than R5 million per annum in the early 1990s (Mouton 2003: 240) to over R130 million per annum for the 2004/05 year (OECD 2007: 121). A general
principle is that THRIP funding must be complemented by industry funding (on a 1:2 basis for larger firms).

**Innovation Fund:** Set up under DACST and now administered by the NRF for the DST, this provides competitive funding for collaborative research projects that may generate new products and processes for commercialisation or new methods for service delivery. At the time of the OECD review, 33 per cent of funding had been received by the private sector, 39 per cent by the science councils and 28 per cent by the universities, with an Innovation Fund budget of just over R200 million per annum (OECD 2007: 123).

**BRICs:** Arising out of the 2001 Biotechnology Strategy, these centres aim to provide a regional nucleus for the development of biotechnology platforms. Essentially, BRICSs (with DST funding at the level of R150 million in 2005) work together with industry and universities.

**CoEs:** An initiative of the DST, administered by the NRF, these centres commenced in 2004 when six CoEs were awarded on a competitive basis (out of 70 applicants) to the University of Stellenbosch (1, plus 1 co-hosted), the University of the Witwatersrand (1, plus 1 co-hosted), UCT (2), and the University of Pretoria (1), each with an annual budget of R5 million (OECD 2007: 120). Although one university acts as host (or sometimes co-host), this CoE approach aims to join researchers across universities and other research groupings, including in industry, in other words, the conception of each CoE is a ‘multi-institutional network of researchers’.

**Research Chairs:** Modelled on the Canadian Research Chair system (see Chapter 3), the SARChI, funded through the DST and driven by the NRF, began in 2006 with the award of 21 research chairs on a competitive basis, and with the aim of creating 210 research chairs by 2010. A further 55 were awarded in 2007, with over R200 million already allocated by then (NRF 2007). By 2007, 37 per cent of awards were to black candidates, with the goal of 60 per cent black and 50 per cent female chairs by 2010 if possible (neither this goal, nor the aim of creating 210 research chairs has been achieved). SARChI’s aims are to ‘increase the number of world class researchers in South Africa…retain and/or attract back [from abroad] qualified researchers…to stimulate strategic research across the knowledge spectrum…and to improve and accelerate the training of highly qualified personnel through research’ (NRF 2007). Funding per annum was initiated at R2.5 million per research chair for five years, potentially renewable for two further periods of five years.
R&D indicators: Selective insights into our national system

This section summarises a selective set of indicators of South African and comparative international R&D expenditure and research personnel data, covering the period around 2005 – the mid-point of interview fieldwork for this study. The aim is to provide certain perspectives on national R&D activity, to enable references and interpretations to be made later in discussion of the Western Cape case study data. In addition, at the end of this section some indicators of research capacity per HEI are provided for the diverse group of South African HEIs, in order to locate the five Western Cape HEIs (where the case study units/groupings are based) within the overall national framework of HEIs which existed around the time of the 2005 interviews.

Some R&D expenditure indicators

South Africa has a long history of measuring its systems of R&D, and very recently of innovation – with surveys of research and experimental development going back as far as 1968. The more recent R&D surveys measure the inputs to R&D, namely finance and personnel and, as noted earlier (see endnote 2), follow the guidelines of the *Frascati Manual* of the OECD (OECD 2002), which allows for international comparability. Up to survey year 2003/04, the R&D surveys were biennial; they are now annual. These surveys provide a rich source of quantitative data and indicators.

The most widely used indicator of R&D is the ratio of Gross Expenditure on R&D (GERD) to GDP. This is displayed in Table ii.1, for the period 2001–06.

<table>
<thead>
<tr>
<th>Year</th>
<th>2001</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>GERD:GDP</td>
<td>0.73</td>
<td>0.8</td>
<td>0.86</td>
<td>0.92</td>
<td>0.95</td>
</tr>
</tbody>
</table>

Source: OECD (2008: 2)

Note: Data for the years before 2001 (also given in OECD 2008) are not shown because, especially between 1993 and 2001, there are some doubts as to accuracy due to debates around defence expenditure and also effects of different organisations undertaking the surveys over this period (see Kahn & Blankley 2006). Note that from 2001 all surveys were undertaken by the HSRC.

For the surveys after 2001, it can be observed that there has been a steady annual increase in GERD:GDP, rising from 0.73 per cent at the time of the first HSRC survey to 0.95 per cent by 2006, and thus approaching the desired target of 1.0 per cent set in the DST’s 2002 R&D Strategy. This does suggest that at least in terms of this target, this Strategy, discussed earlier, has been relatively successful.

International comparisons for 2005 are provided in Table ii.2, which shows the ratios for GERD to GDP, business expenditure on R&D (BERD) to GDP, and business’s contribution to expenditure on higher education R&D (HERD). Here a group of industrial countries, including Sweden, Japan, Korea, the USA and Singapore, heads
the list with GERD:GDP above 2.0 per cent. This is followed by countries such as Canada, the UK and the Netherlands, each with a figure slightly below 2.0 per cent. South Africa, with close to 1.0 per cent, is among a group that includes New Zealand, Spain, Portugal, Brazil and Turkey, well below the leaders – but nonetheless considerably above countries such as Greece, Poland, Argentina and Mexico that fall around the 0.5 per cent level.

Table ii.2 A global snapshot of overall and business investment in national R&D, 2005

<table>
<thead>
<tr>
<th>Country</th>
<th>GERD:GDP (%)</th>
<th>BERD:GERD (%)</th>
<th>HERD from Business (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>0.46</td>
<td>32.2</td>
<td>0.6</td>
</tr>
<tr>
<td>Australia</td>
<td>1.78</td>
<td>54.1</td>
<td>5.7</td>
</tr>
<tr>
<td>Brazil</td>
<td>0.97</td>
<td>31.0</td>
<td>n.a.</td>
</tr>
<tr>
<td>Canada</td>
<td>1.98</td>
<td>53.9</td>
<td>8.3</td>
</tr>
<tr>
<td>Greece</td>
<td>0.51</td>
<td>31.0</td>
<td>8.9</td>
</tr>
<tr>
<td>Japan</td>
<td>3.38</td>
<td>75.1</td>
<td>2.8</td>
</tr>
<tr>
<td>Korea</td>
<td>2.98</td>
<td>76.9</td>
<td>15.2</td>
</tr>
<tr>
<td>Mexico</td>
<td>0.5</td>
<td>49.5</td>
<td>1.1</td>
</tr>
<tr>
<td>Netherlands</td>
<td>1.73</td>
<td>58.3</td>
<td>6.8</td>
</tr>
<tr>
<td>New Zealand</td>
<td>1.17</td>
<td>41.8</td>
<td>8</td>
</tr>
<tr>
<td>Poland</td>
<td>0.57</td>
<td>31.8</td>
<td>5.4</td>
</tr>
<tr>
<td>Portugal</td>
<td>0.81</td>
<td>38.5</td>
<td>1.2</td>
</tr>
<tr>
<td>Singapore</td>
<td>2.36</td>
<td>66.2</td>
<td>n.a.</td>
</tr>
<tr>
<td>South Africa</td>
<td>0.92</td>
<td>58.3</td>
<td>11.6</td>
</tr>
<tr>
<td>Spain</td>
<td>1.12</td>
<td>53.8</td>
<td>6.9</td>
</tr>
<tr>
<td>Sweden</td>
<td>3.71</td>
<td>77.6</td>
<td>5.2</td>
</tr>
<tr>
<td>Turkey</td>
<td>0.79</td>
<td>33.8</td>
<td>22.7</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>1.78</td>
<td>62.1</td>
<td>4.6</td>
</tr>
<tr>
<td>United States</td>
<td>2.62</td>
<td>69.8</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Sources: OECD (2008: 2); data for Brazil from RICYT (2008)

Note: n.a. = no data available

The major reason for South Africa being quite high on the list can be deduced from the second column of Table ii.2: our BERD as a percentage of GERD is 58.3 per cent. While this is about 15 per cent lower than the very top group (Sweden, etc.), it is close to 60 per cent, which puts South Africa in the company of a second group comprising Singapore, the UK and the Netherlands. In other words, our GERD is being kept ‘floating high’ by the strong input of BERD, which is relatively higher than in countries such as Australia, Canada, Spain and Mexico (all around 50+ per cent), and far higher than in countries such as New Zealand, Turkey and Brazil (around 40 per cent or less) with whom South Africa is of similar rank with respect to GERD:GDP.13
Another way of looking at business’s impact on South African GERD is through the data in the third column of Table ii.2. The percentage of HERD derived from business is well below 10 per cent for almost all the countries that are above South Africa with respect to GERD:GDP (first column), for example Japan (2.8 per cent), the UK (4.6 per cent), the USA (5.0 per cent), Sweden (5.2 per cent), Australia (5.7 per cent), the Netherlands (6.8 per cent), Spain (6.9 per cent), New Zealand (8 per cent) and Canada (8.3 per cent) – only Korea (15.2 per cent) and Turkey (22.7 per cent) stand above South Africa. Our universities are therefore strongly dependent on business funding for their research – a vital point of analysis in Parts 2 and 3 of this book, which will reveal the extreme financial fragility of many of the Western Cape research groupings.

Table ii.3 details the research expenditure of the main performers of R&D within South Africa for 2005/06 in terms of sources of funds. Overall, business (including industry) is the dominant source, followed by higher education and then the science councils.

<table>
<thead>
<tr>
<th>R&amp;D performer</th>
<th>Business</th>
<th>Government</th>
<th>Higher education</th>
<th>Not-for-profit</th>
<th>Science councils</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source of R&amp;D funding</td>
<td>R000s</td>
<td>%</td>
<td>R000s</td>
<td>%</td>
<td>R000s</td>
</tr>
<tr>
<td>Internal</td>
<td>5 488 727</td>
<td>66.6</td>
<td>316 145</td>
<td>37.4</td>
<td>1 601 444</td>
</tr>
<tr>
<td>Government</td>
<td>1 331 740</td>
<td>16.2</td>
<td>439 511</td>
<td>52</td>
<td>491 784</td>
</tr>
<tr>
<td>Business</td>
<td>142 256</td>
<td>1.7</td>
<td>11 000</td>
<td>1.3</td>
<td>316 740</td>
</tr>
<tr>
<td>Other</td>
<td>84 282</td>
<td>1</td>
<td>19 270</td>
<td>2.3</td>
<td>16 657</td>
</tr>
<tr>
<td>Foreign</td>
<td>1 196 771</td>
<td>14.5</td>
<td>58 714</td>
<td>7</td>
<td>305 590</td>
</tr>
<tr>
<td>Total</td>
<td>8 243 776</td>
<td>100</td>
<td>844 640</td>
<td>100</td>
<td>2 732 215</td>
</tr>
</tbody>
</table>

Source: HSRC (2008a: Table 1.3)

With regard to higher education, one observes that, in addition to the 11.6 per cent derived from business for the period 2005/06, the funding from foreign sources was also substantial at 11.2 per cent. The relatively small government flow to higher education (18 per cent) is misleading, in that the internal research funds of HEIs (58.6 per cent) are largely derived from government in the form of the annual higher education subsidy. Thus, overall government provides the main share of 76.6 per cent (58.6 plus 18) while, as noted, the share of business is higher than in many other countries.

The pattern for the science councils is quite close to that of higher education: 75.7 per cent overall from government (52.6 plus 23.1), 10.5 per cent from business, and 12.1 per cent foreign (note, however, that for the non-profit or largely NGO sector, this rises to 45.2 per cent). For business itself, it can be observed that it is a major source of funding for its own R&D, 68.3 per cent (66.6 plus 1.7), with nonetheless a large foreign flow to business (14.5 per cent, concentrated in clinical trials).

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The relatively large flow of government funds to business (16.2 per cent) arises through support to SOEs (see endnote 13).

Important also to note from this same HSRC (2008a) study are the data which are classified according to the (Frascati Manual) categories of ‘basic’, ‘applied’ and ‘experimental’ research. Here it emerges that business is clearly oriented primarily towards the applied and experimental side, with only 8.7 per cent (HSRC 2008a: Table H9) categorised as basic. For the sectors of government, not-for-profit and science councils, the applied side is also dominant, with basic research at around 25 per cent for each (25.3 per cent, 25.5 per cent and 24.9 per cent from Tables G6, N5 and S5 respectively). In contrast, for higher education the basic research component of just over 41.5 per cent (HSRC 2008a: Table H5) is considerably higher, although interestingly still less than the applied side (identified as ‘applied’ and ‘experimental’ research according to this survey).

Higher education is thus crucial in South Africa as the main provider of what has in Part 1 been categorised as PBR, with the two other major research sectors – the science councils and business – much more oriented towards the applied side (even though use-oriented research, UIBR+PAR, is significant too within the higher education sector).¹⁴ Comparative international data, moreover, suggest that, while for South Africa the figure for basic research as a percentage of GDP is around 0.2 per cent, for the USA and Sweden it is 0.5 per cent and for South Korea 0.4 per cent (OECD 2008: Table 6). This suggests that not only is South Africa spending considerably less on basic research relative to GDP than these countries, but also that where there is orientation towards the basic side of research (both PBR and UIBR) in South Africa, it is to be found primarily within our higher education sector. The fragile and insecure nature of this foundation of PBR and UIBR within universities will be highlighted with respect to the Western Cape case studies in later chapters.

Some indicators of research personnel and research outputs

In the analyses of the 11 cases which follow, access to research personnel – especially senior researchers – will be seen as perhaps even more vital in determining their fate than research funding (although the two are interconnected). Thus another important set of national South African indicators pertains to the availability of researchers. Table ii.4 provides some insights into this.

Table ii.4 R&D researchers (FTE), 1992 and 2005

<table>
<thead>
<tr>
<th>Sector</th>
<th>1992</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business</td>
<td>3 395</td>
<td>6 355</td>
</tr>
<tr>
<td>Government</td>
<td>2 428</td>
<td>1 974</td>
</tr>
<tr>
<td>Higher education</td>
<td>3 631</td>
<td>3 555</td>
</tr>
<tr>
<td>Total</td>
<td>9 454</td>
<td>11 884</td>
</tr>
</tbody>
</table>

Sources: HSRC (2008b); Kahn & Blankley (2006: 282)

Notes: FTE = full-time equivalent
The figures exclude doctoral and post-doctoral students.
Table ii.4 suggests that business was already relatively strong with respect to FTE researchers in relation to higher education in 1992. Moreover, the total number of FTE researchers in the higher education and government sectors (including the science councils) remained almost static over this period (with the government sector particularly appearing to have declined).\textsuperscript{15} For the country as a whole, but especially with respect to higher education, this does not suggest a story of the flowering of quantities of research workers. Quite the contrary: there appears to be stagnation and even decline in absolute numbers of researchers (except in business).

The problem of the relatively low level of researchers in South Africa as a whole is further highlighted by Figure ii.1. According to the standard international indicator of FTE researchers per 1 000 total employment, it can be observed that South Africa falls on the low side, close to countries of Latin America and far below countries such as New Zealand at 10.5, Chinese Taipei at 8.9 and the OECD average of 6.0.

\textbf{Figure ii.1 Full-time equivalent researchers per 1 000 total employment}

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure.png}
\caption{FTE researchers per 1 000 total employment}
\end{figure}

It can be noted, however (see Figure ii.2), that women comprise nearly 40 per cent of researchers (by headcount) in higher education in South Africa, while for the science councils the figure is just over 35 per cent, placing South Africa among the more ‘gender equal’ in terms of researcher profile internationally.\textsuperscript{16}

But the situation becomes more complex when demographics of race and age are considered (Figure ii.2). Kahn and Blankley (2006) have shown that only 25 per cent of higher education researchers are black;\textsuperscript{17} for the science councils the proportion is 28 per cent and for business 21 per cent. While this is a marked improvement from the unacceptably low base of the early 1990s, for many reasons the transformation agenda has not produced the rapid results expected of it. One proposed reason for this is that positions in government administration and business are attractive to young black scientists; another is the sheer opportunity cost of devoting maybe
15 years post-schooling to developing a research career (see later case studies for some confirmation of these reasons). The consequence for higher education is that the strategy of ‘growing our own timber’ has produced very few saplings, let alone trees, so that the academic cadre, as in many countries of the North, is experiencing disciplinary ageing (OECD 2006). Within South African higher education in particular, the dominant mean age for researchers of 45 shown by Figure ii.2 does not augur well at all.

**Figure ii.2 Researchers by institutional type, race, dominant age and gender**

This problem of the ageing nature of university researchers, and associated problems of succession planning for a new generation of black researchers within university research centres, units and departments, will be a major theme in relation to South African higher education policy issues considered in Part 3.

Turning to some selective indicators of research outputs, South African authors make only a modest contribution to world scientific production as measured by peer-reviewed journal publications (King 2004; Pouris 2003). Of note, too, is that the bulk (>80 per cent) of these peer-reviewed journal articles recorded on the Thomson-ISI database come from the universities (SARUA 2008). A crucial point is that the South African share of world production has remained static over the last two decades and is now falling, as the world volume expands with the large contribution of China and the growing importance of India, Korea and other countries such as Brazil.

Similarly, when the production of PhDs is examined, one quantitative indicator – PhD graduates/million of population (Figure ii.3) – shows just how far South Africa has to go.
Specifically, in comparison with the USA and Europe (rates upwards of 100), but also in relation to the transition economies of Eastern Europe (rates upwards of 50) and resource-rich countries like Australia (230) and even Brazil (45), we are lagging significantly behind, at around 25 PhDs per million population.\footnote{19}

At the ‘system’ level of university research productivity, therefore, the above data suggest considerable problems with respect to enhancement of outputs such as the level of scientific publications and PhD graduates. The Western Cape case study analysis will seek to examine some of the ‘blockages’ in relation to these.

**South African universities in 2005: How the five Western Cape HEIs fit in**

It was noted in the Introduction to Part 1 that seven of the 11 cases to be analysed in this study were selected from the three universities of the Western Cape, with the remaining four located in the two universities of technology (which institutions began to merge after 2005). It is relevant to understand how these five Western Cape HEIs fit into the framework of HEIs in South Africa as a whole. Since the focus of this study is the research undertaken by the 11 selected research groupings, Table ii.5 provides ranked data in column 1 for all 30 HEIs, by annual total research expenditure (rands), for the year 2005 – which was almost the ‘mid-point year’ for the interview fieldwork of this study.\footnote{20} Rows containing data for the five Western Cape HEIs are highlighted in the table. Additional research-related indicators are provided in the other three columns respectively: researchers (FTEs), PhD graduates, and publication count (officially accredited).
## Table ii.5 Higher education research-related indicators, 2005

<table>
<thead>
<tr>
<th>Institutions</th>
<th>Research expenditure (rands)</th>
<th>Researchers (FTEs)</th>
<th>PhD graduates</th>
<th>Accredited publications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. University of the Witwatersrand</td>
<td>394 527 000</td>
<td>356</td>
<td>93</td>
<td>557</td>
</tr>
<tr>
<td>2. University of Cape Town</td>
<td>343 119 000</td>
<td>326</td>
<td>99</td>
<td>564</td>
</tr>
<tr>
<td>3. University of KwaZulu-Natal</td>
<td>343 115 000</td>
<td>432.9</td>
<td>98</td>
<td>704</td>
</tr>
<tr>
<td>4. University of Pretoria</td>
<td>310 000 000</td>
<td>465.8</td>
<td>187</td>
<td>954</td>
</tr>
<tr>
<td>5. University of Stellenbosch</td>
<td>283 402 000</td>
<td>322</td>
<td>115</td>
<td>624</td>
</tr>
<tr>
<td>6. University of the Free State</td>
<td>117 037 000</td>
<td>155</td>
<td>58</td>
<td>334</td>
</tr>
<tr>
<td>7. University of South Africa (UNISA)</td>
<td>102 040 000</td>
<td>301.5</td>
<td>109</td>
<td>414</td>
</tr>
<tr>
<td>8. North West University (Potchefstroom)</td>
<td>97 466 000</td>
<td>171.1</td>
<td>87</td>
<td>266</td>
</tr>
<tr>
<td>9. Rhodes University</td>
<td>78 821 000</td>
<td>102.5</td>
<td>40</td>
<td>165</td>
</tr>
<tr>
<td>10. Rand Afrikaans University</td>
<td>75 532 000</td>
<td>159</td>
<td>95</td>
<td>277</td>
</tr>
<tr>
<td>11. University of the Western Cape</td>
<td>73 354 000</td>
<td>118.5</td>
<td>23</td>
<td>106</td>
</tr>
<tr>
<td>12. Tshwane University of Technology</td>
<td>45 257 000</td>
<td>62.6</td>
<td>9</td>
<td>72</td>
</tr>
<tr>
<td>13. University of Port Elizabeth</td>
<td>31 736 000</td>
<td>44.6</td>
<td>26</td>
<td>123</td>
</tr>
<tr>
<td>14. Durban Institute of Technology</td>
<td>29 854 000</td>
<td>80.7</td>
<td>3</td>
<td>27</td>
</tr>
<tr>
<td>15. University of the North</td>
<td>23 089 000</td>
<td>58.2</td>
<td>14</td>
<td>63</td>
</tr>
<tr>
<td>16. Vaal University of Technology</td>
<td>21 753 000</td>
<td>28.5</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>17. University of Fort Hare</td>
<td>21 369 000</td>
<td>57.4</td>
<td>2</td>
<td>79</td>
</tr>
<tr>
<td>18. Cape Technikon</td>
<td>20 123 000</td>
<td>26.2</td>
<td>1</td>
<td>20</td>
</tr>
<tr>
<td>19. Technikon Witwatersrand</td>
<td>19 528 000</td>
<td>30.6</td>
<td>0</td>
<td>16</td>
</tr>
<tr>
<td>20. Central University of Technology</td>
<td>15 764 000</td>
<td>25</td>
<td>7</td>
<td>21</td>
</tr>
<tr>
<td>21. Port Elizabeth Technikon</td>
<td>14 379 000</td>
<td>22.5</td>
<td>9</td>
<td>32</td>
</tr>
<tr>
<td>22. University of Zululand</td>
<td>12 189 000</td>
<td>29.4</td>
<td>29</td>
<td>61</td>
</tr>
<tr>
<td>23. Medical University of South Africa</td>
<td>10 127 000</td>
<td>28.5</td>
<td>6</td>
<td>50</td>
</tr>
<tr>
<td>24. Peninsula Technikon</td>
<td>8 441 000</td>
<td>9.2</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>25. University of Venda for S&amp;T</td>
<td>7 400 000</td>
<td>13.2</td>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>26. University of Transkei</td>
<td>7 285 000</td>
<td>25</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>27. Eastern Cape Technikon</td>
<td>7 031 000</td>
<td>22.6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>28. North West University – Mafikeng</td>
<td>5 981 000</td>
<td>10</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>29. Mangosuthu Technikon</td>
<td>2 263 000</td>
<td>6</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>30. Border Technikon</td>
<td>1 508 000</td>
<td>2.9</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2 523 490 000</strong></td>
<td><strong>3 493.4</strong></td>
<td><strong>1 120</strong></td>
<td><strong>5 598</strong></td>
</tr>
</tbody>
</table>

Source: Kahn et al. (2007: 182)
An important finding from Table ii.5 is that there is a clear clustering of the HEIs of the ‘new South Africa’ into three groups, with respect to this set of research indicators:

- five relatively research-intensive universities, far above the others in terms of aggregate research activity;
- six universities with a very moderate research profile;
- the remaining HEIs with a relatively weak research profile.

With regard to the Big Five (the universities of the Witwatersrand, Cape Town, KwaZulu-Natal, Pretoria and Stellenbosch) – all historically white and originating from the elite group of colonial university colleges which emerged even before Union in 1910 (see Cooper & Subotzky 2001: Chapter 1) – it can be seen that in 2005 they still headed the list. For example, annual research expenditure for each of them was above R250 000 000, their researchers numbered above 320 FTEs, and their accredited publication counts were above 550 – all well above the levels of the Next Six. In fact, their total share of HERD expenditure was 66 per cent, of FTE researchers 55 per cent, of PhD graduates 53 per cent and of accredited publications 61 per cent (Kahn et al. 2007: 181).

Table ii.5 shows that there is a big gap between the Big Five universities and the Next Six: for research expenditure, the drop is over R150 000 000 from number five to number six in the ranking, for researcher FTEs over 150, for publications well over 200.21 The Next Six, in terms of these indicators, are thus defined as separate – but they are also separate from the Third Group of 19 below them in the table. Importantly, too, this least research-active Third Group, except for the University of Port Elizabeth, all had their origins either as technikons or as historically black universities; in contrast, all members of the Next Six group above them had origins as historically white universities (except UWC, a historically coloured university).22

Finally, of relevance here are the positions in Table ii.5 of the five Western Cape HEIs, which form the focus of the analysis in the chapters that follow:

- the universities of Cape Town and Stellenbosch are up in the Big Five;
- the University of the Western Cape, the only university not historically white within the Next Six, scores lowest in this second group for most of the research indicators;
- the Cape Technikon (a historically white technikon) is about one-third down in the Third Group in terms of research expenditure, and the Peninsula Technikon (a historically coloured technikon) about two-thirds down.

One should be wary, however, of simply reading off ‘research performance’ from where a university is ranked according to the indicators of Table ii.5. For example, if one ‘normalises’ PhD graduates and accredited publications by dividing by researcher FTEs per institution, it is found that some universities in the second group are more efficient23 in their research output than some of the Big Five, for example the smaller, historically white universities like North West (Potchefstroom), Free State and Rhodes performed relatively well in 2005. In fact, if one considers qualitative indicators as well – such as research creativity and stability of some research groupings – one of the most successful and dynamic research centres of all
11 Western Cape cases was to be found within one of the former technikons. This points to the fact that, under specific conditions, high-quality research performance may occur anywhere in the higher education system.

One of the major aims of the case study analysis in Part 2 is to explore such issues in detail in the context of the Western Cape.

Notes
1 This Introduction to Part 2 was written jointly with Michael Kahn.
2 The concept of innovation used in this Introduction follows the Oslo Manual definition of innovation as in essence the implementation of a new product, or process of organisational method (OECD 2005b). Until the early 1990s, the conventional outputs of ‘innovation systems’ were taken to be postgraduates, especially doctoral graduates, journal publications, patents and royalty income streams. Academic studies on the role of knowledge and innovation in economic growth, together with a revival of interest in the seminal work of Schumpeter, spurred the OECD first to develop a systematic approach to measuring research or new knowledge production (see Chapter 2 of OECD 2002 with respect to the Frascati Manual for measuring R&D), and then to measuring innovation, especially in the business sector. The latter approach built on the success of the Frascati Manual and is codified in the Oslo Manual (OECD 2005b), which provides guidelines for the conduct of innovation surveys. South Africa conducted its first official innovation survey for 2002–04, Innovation Survey 2005 (HSRC 2008b). See also some of the tabular data presented later in this Introduction.
3 Of course, this neglects the history of informal innovation within the agricultural societies of southern Africa, where development of new knowledge and associated new products was an ongoing process over the centuries.
4 See Cooper and Subotzky (2001: Chapter 1, especially Table 1.1), which indicates how, in addition, two coloured and Indian universities had been established as well as two other African universities (one for training of medical personnel, and one an ‘anomaly’ for urban African students) – making up a total of 21 universities by the 1980s.
5 The eight science councils were: the CSIR, the Human Sciences Research Council (HSRC), the Medical Research Council (MRC), the Council for Minerals Technology (MINTEK), the Agricultural Research Council, the National Research Foundation (NRF), the Council for Geoscience (CGS) and the South African Bureau of Standards (SABS). They were later supplemented by a ninth council, the Africa Institute of South Africa (AISA).
6 This is because the subsidy formula for higher education (and hence the higher education share of the Education Vote) is primarily (about 70 per cent) based on student numbers (mainly enrolments, but also partly numbers actually graduating). This means in effect that the salaries (paid by the universities from the government education subsidy allocated to them) for academic staff – and hence the bulk of academics’ paid time-for-research – derive very heavily from the student numbers of a university.
7 As noted, around 70 per cent of subsidy derives from student numbers; under 15 per cent derives from the new component noted here.
8 In 2002 the previous DACST was split into the DST and the Department of Arts and Culture (DAC).
9 However, the ‘Ten-Year Innovation Plan’ (2008), noted below, emerged after the completion of the fieldwork undertaken with respect to the case studies; thus, while important, this initiative will only be touched on here.

10 Rand amounts are cited for the period of the OECD review (often for the 2004/05 financial year), since this is the relevant period with respect to the fieldwork undertaken with respect to the 11 Western Cape case studies.

11 See Chapter 3 for theoretical discussion of this type of NoE.

12 It should be noted that, by 2008, over 80 per cent of the research chairs had been awarded to the 'Big Five' universities, with fewer than 5 per cent going to historically black universities and the ex-technikons (now universities of technology).

13 State-owned enterprises that perform R&D, and that trade at market prices, are included in the South African business sector. This accords with Frascati Manual guidelines. It is significant that these present and former SOEs (such as SASOL) contribute close to 20 per cent of BERD. The state has been, and still is, an important R&D incubator (see further in Kahn & Blankley 2006).

14 Note that in the HSRC (2008a) survey, there might be some dispute about how survey respondents interpreted the 'pure', 'applied' and 'experimental' research categories, especially if compared to Stokes's categories of PBR, UIBR and PAR. Nonetheless, the data cited in the previous paragraph do provide a rough guide to the fact that the higher education sector is much more oriented PBR than the other sectors.

15 However, it is important to note that despite the lack of increase in the number of researchers in government, the proportion of black researchers has increased significantly (Kahn 2010). Thus, employment equity is moving forward within a static workforce, which implies an exit of skill and its replacement with new entrants.

16 In total, women researchers in South Africa comprise 38 per cent of all researchers, compared, for example, to 51 per cent in Argentina, 43 per cent in Russia, 11 per cent in South Korea and 28 per cent in Norway (OECD 2007: 97).

17 Black is here defined as African, coloured and Indian.

18 Of note here is that along with a tripling of the number of South African journals that are indexed on this Thomson-Reuters Web of Science database, there has been a sharp increase in the number of articles published by South African authors – though it is not suggested that this increase is primarily due to the increase in indexing.

19 This is only one quantitative measure of PhD production, however – see also Cooper (2006) for a discussion of qualitative measures such as high-quality coursework components of a PhD (which are lacking in South Africa), and also the fact (Bailey & Cooper 2003) that the vast number of PhD graduates of our university system are white students – and this has not changed very significantly in recent years.

20 Note that the original 36 universities and technikons (see Cooper & Subotzky 2001) had already, in the few years prior to 2005, been reduced through early mergers to a set of 30 HEIs as shown in Table ii.5.

21 The distance learning University of South Africa (UNISA) appears as a slight anomaly, but with its very large student base and hence large academic staff complement, it can be expected that its overall totals for researcher FTEs (301.5) and accredited publications (414)
would fall below the Big Five, but not by as much as the others within the Next Six (and its PhD graduate numbers are actually slightly above some of the Big Five). However, if one makes a comparison in terms of efficiency criteria, computed for example by PhD graduates per researcher or accredited publication outputs per researcher, it can be seen that UNISA in fact falls towards the bottom of the Next Six.

22 See also Kahn et al. (2007: 183–184), where it is noted briefly that, by the end of 2006, the 30 institutions shown in Table ii.5 had, through a final set of mergers, become 23 – with the result that the Next Six became the Next Seven (the seventh being a result of a larger institution, Nelson Mandela Metropolitan University, arising from the merger of the university and technikon of Port Elizabeth). But except for this change, the historically white Big Five remained strongly dominant, with the Third Group (now only 11 due to a set of mergers) still far below, and based now entirely on institutions which were historically either technikons or black universities.

23 For example, the measurement of PhD graduates per FTE researcher is a rough indicator of the number of PhDs each staff member is producing; similarly for accredited publications.
Use-oriented research: ‘Model types’ of research groupings in the universities

This chapter and the next describe detailed investigations of 11 research groupings at universities (including universities of technology) in the Western Cape. The analysis seeks to grasp the most important underlying factors within the universities, and within the research groupings themselves, that enhance or inhibit the development of use-oriented research (both UIBR and PAR).

The focus of analysis is the three cases – Cases 1, 2 and 3 – which most graphically exemplify the three use-oriented research models A, B and C respectively (see Figure 4.1). These models and associated cases serve to illustrate key features of what in Part 1 was called a second academic transformation, itself linked to the third university mission of socio-economic–cultural development. An understanding of these three model types requires a prior appreciation of what has been referred to as a ‘traditional (virtual) unit’ (virtual in the sense that it is not recognised by its members as a formal unit structure) – Model T, with its curiosity-oriented (PBR) research rooted in the first academic transformation; this is addressed in the chapter by means of the analysis of Case 0 (called the Science (Virtual) Unit).1

Figure 4.1 Transformation of traditional Model T into new Model A, or B or C

First academic transformation

Second academic transformation

Use-oriented (UIBR+PAR)

Curiosity-oriented (PBR)

MODEL T
Traditional (Virtual) Unit
(exemplified by Case 0)

MODEL A
New (Real) Centre
(exemplified by Case 1)

MODEL C
New (Virtual) Centre
(exemplified by Case 3)

MODEL B
New (Real) Unit
(exemplified by Case 2)

Note: Refer also to Chapter 3, Figures 3.1–3.4.

A major focus of analysis for each case study is the internal mode of organisation of the research entity, as identified during the first phase of interviews in 2000, and how this changed over the period 2000–04 (prior to the second phase of interviews), and
again over the period 2005/06 (prior to the third phase of interviews). As suggested in the Introduction to Part 1, this 'trend analysis' over seven years provides not only many insights into the internal structures of these research groupings, but also significant understanding of the key factors enhancing or inhibiting use-oriented research – both UIBR and PAR – at our universities.

Case 0: The ‘traditional’ Model T structure, exemplified by the Science Unit

In order to capture adequately both the core internal structure of the ‘traditional’ research grouping and the powerful spirit of curiosity-oriented research or PBR underlying it, this case study provides extensive verbatim extracts from the interview with the head of the grouping, Prof. Science. The first interview was conducted in 2000, in which he effectively articulated many of the features of this model. In fact, Prof. Science was deliberately selected because, in an informal encounter a few months before, he had expressed problems with my study focusing only on application-oriented research groupings. The interview therefore began by focusing directly on this question:

Interviewer [in 2000]: When we set up this interview, you mentioned, when we were speaking about the applied research units which is our focus of research, that you operate in a, what you termed, traditional way. So I thought I'd start by asking you to explain what you mean by ‘traditional way’. In other words, how do you manage the research at your M Department?

Prof. Science: Right. Well, the traditional way, which most of us at my M Department operate in, is merely that any individual academic will carry on her or his research work probably, but not always, with graduate students – Honours, MSc, PhD students – working on their own – in other words, the staff member and the students. Or sometimes one staff member [works] together with another staff member and their common graduate students, and very rarely more than two staff members, say three. And it is done without there being a formal thing like a unit or a centre.

To illustrate how pervasive was this traditional approach of ‘little science’ (see Chapter 3) – of an ‘informal’ (virtual) research unit with a professor and his (or sometimes her) postgraduate students at the core – Prof. Science spontaneously opened up the page of the M Department in a recent Science Faculty handbook of this university on the desk. He went through the list of academic staff listed there, indicating how many of them worked in a similar way, alone or with one or more graduate students, sharing departmental equipment where necessary but otherwise pursuing their own individual research agendas. He mentioned, too, that he and most of his colleagues were linked also in informal ways with other science researchers internationally who were working in the same research niche area, and he concluded:
And so we have run through the whole list of the senior people in the M Department who all are doing research, none of whom are in units. Now there is, it is true, in the M Department a substructure which is called The Institute of [AA, a subfield of research], but it is a completely paper structure. It was, I think, the guys who formed it hoped when they set it up that they would get extra money for it and it turned out that the university didn't give them extra money. The only evidence that there is a structure called The Institute of [AA] is that they have got a letterhead. Okay? But there is no… it is a virtual structure. There are no special rooms, there are no special entrances, there are no special fundings. They don't have technicians, they don't have special computers.

He summarised this demonstration of the departmental approach to research with the comment:

So my entire M Department… works, if you like, on the traditional method, which is that the university gives you the space. They give you a desk. They give you some time. You have access to departmental funds for computing and the computer network. These wires in the wall are all put in by the department. And the university produces the students. A senior professor can select students in the third or fourth year and say – and offer them ‘Would you like to work on this project?’ and then the student will either get a scholarship on their own merits or perhaps the professor has some research money that he can offer the student research money from. And so the research proceeds like that. It is different, it sure is different to the model used elsewhere in the university where you have big units… [mentions a few big, structured research units and centres also in this science faculty]. And I would think at least half of the research in [name of] Faculty goes on in the traditional structure – non-units!

A crucial point emerging, therefore, is that a more formal unit or centre – very important for many of the use-oriented case studies which follow – is viewed by many professors, like Prof. Science, as simply not necessary for pursuing their PBR work. A looser, small virtual unit, frequently built around ‘the lab’ (or in fields like the social sciences, around a small ‘research group’), is often all that seems to be needed. This tradition of (un)organised research, rooted in the German ‘professor-chair’ system of the first academic transformation, was embodied when this university and its research emerged in the Cape Colony in the late nineteenth century (Cooper & Subotzky 2001: Chapter 1). It will be seen from the other 10 cases that their universities (even the universities of technology) are most familiar and comfortable with this ‘virtual unit’ organisational form – with a professor-PI as its core element – which provides a coherent departmental-level ‘shell’ for research work.

As a result of the above discussion, the interviewer 6 decided to pursue the issue of how exactly, within this ‘traditional’ mode, some directions of research were pursued rather than others:
Interviewer [in 2000]: Can I then ask…You say that is the way research happens. Then how are the research problems selected?…

Prof Science: …[There] are certain things we don't do because of two reasons: (a) it is too expensive or (b) we just, because we have a small staff of only 12 people, we're not going to cover everything.

Secondly, the policy we try to follow is that we don't want every single person working on their own in one area so that you have one person per area, because then there's not enough critical mass. So we like to have two or three people working in an area. We haven't as a matter of policy decided, 'We don't like area A so we are going to scale it down and get rid of those guys because we do like area B so we are going to push these people out and create new positions and pull people in.' We haven't done that. We've moved, if you like, in a historical way. When Mr A retires, if we can find a good candidate in that sub-discipline so that he can work with the guy's colleagues, we do so, and if we can't then we would just take the best candidate in any field. So it is not a highly directed policy. We tend to go for the best person in an existing area and if we can't get an existing area where there is a vacancy, if we can't get that then we just go for the best person in one of the areas we are working in.

Interviewer: This being basic research, I assume you publish internationally?

Prof. Science: Yes.

The above interview extract highlights a mode of selecting research directions very different from that pursued by someone like Frederick Terman at Stanford University after the Second World War. Terman, as dean of Engineering, pursued a policy – linked to his strategy of consolidating larger research centres and networks – of deliberately selecting new academics who could fit into subfields of research already established, or becoming established, within a department (see Chapter 2). He actively sought to build up selected research niches within and across departments with respect particularly to the UIBR which he was trying to grow at Stanford, and trying to link with local industries. This approach is very different from that of the PBR philosophy of the first academic transformation captured so clearly in the above discussion with Prof. Science.

As will be seen in the case studies that follow, it is because of links with 'clients' or stakeholders outside the university that use-oriented research directions and research programmes other than PBR slowly become constructed and consolidated. For Prof. Science, however, it was not clients, but rather the international community of peer researchers in the subfield, that informally shaped the research direction and the orientation towards publication in international academic journals.
PBR at our universities: Problems articulated in 2000

Most of the 10 cases that follow are experiencing a combination of ‘chaos and creativity’ in relation to the use-oriented research which they are pursuing (see Cooper 2001). The interview with Prof. Science in 2000 suggested that in the case of PBR, too, many researchers at South African universities felt they were conducting research in difficult circumstances which created chaos for them, but for different reasons. Later in this book it will be stressed that in addition to new policies needed to enhance use-oriented research at HEIs in South Africa, new policies are equally needed to enhance PBR. This is not only because such ‘pure’ research is essential for any national intellectual culture to flourish per se, but also because all UIBR needs, as its foundation, good and enthusiastic PBR professors like Prof. Science in order to develop.7

Further quotations from the Case 0 interview highlight two sets of difficulties experienced in this ‘traditional’ research grouping – a shortage of post-docs, and an undervaluation of basic research – both of which were viewed as important by Prof. Science in relation to PBR in South Africa.

Shortage of post-docs

Interviewer: Compared to the situation of professors in other countries and the kind of staff support they have, does this not put you into a relative disadvantage, for instance, not having a post-doc between yourself and students?

Prof. Science: Yes. One of the biggest weaknesses in [this] Faculty is the lack of adequately funded post-doctoral students...You have to use your research grant, which you might get from the NRF, and instead of spending it on, say, going to conferences or buying equipment, you could decide you want to hire a post-doc. The difficulty with that is the size of the grants are generally so small that hiring a post-doc would use up either 90 per cent or all of it, leaving nothing left over...

The other thing that works against it is the following. Because the science community in South Africa is small and because the number of good institutions is even smaller...it turns out that if somebody is good enough to be considered for a post-doctoral research fellowship at [this university] they will almost certainly be good enough to be considered for a senior lectureship, a permanent job somewhere else. What does a young guy of 25 do, say, two years after his doctorate? Or a young woman. They are faced with a research fellowship at [this university], which is a temporary job for three years, or the offer of a permanent job at institution D. Eighty per cent of the people go for the – unfortunately from the point of view of research but maybe sensibly from the point of view of a lifestyle – they go for a permanent job at institution D, where they do more teaching and
less research. So that is the factor that applies here. Certainly that doesn't operate in France, England, America or Germany...

It will be argued in relation to the next case, Case 1 – the ‘Agriculture Centre’ – that a career track for senior researchers, whom I shall term mid-career ‘associate professor-researchers’ or senior research fellows, is absolutely vital if larger research centres are to survive at our universities. It can be seen that for Case 0 also, the layer below senior researchers, that of post-docs, is vital and needs to be better resourced and better coordinated.

Perceived undervaluation of basic research

The interview explored Prof. Science's views on the problem of undervaluation of basic research over the decade prior to 2000, particularly at the historically English-language ‘leading’ universities in South Africa. The professor mentioned the 1980s system of research funding, especially for A-rated individual experienced researchers, and outlined what he perceived as first, second and third shifts in research funding from the late 1980s onwards:

So it [this mid-1980s research funding] favoured the people with a good track record and it disfavoured the people with either mediocre, a poor track record or the very young people, people starting out, who hadn't had time to develop...And when they allocated the money – and they did it by international reviews – the people who ended up getting most of the money tended to be, not always, but there was a concentration at the English universities – UCT, Wits and Natal – and there was a deficit, less than average, at the Afrikaans universities. The black universities got almost nothing...

From the point of view of this professor, a first shift, from the late 1980s following pressure from Afrikaans and historically black universities, involved an attempt to spread research funding much more widely across the South African system of HEIs. Then followed a second shift in the early 1990s, to assist black individual researchers, focusing particularly on:

...potential, people who hadn't had a large output but looked as though they were promising. And so there was the second wave, the second readjustment, which took the money away from the good pure researchers and gave it to the developing researchers.

Finally, he argued, there was a further shift, after the mid-1990s, towards more use-oriented research:

...there was the move in the country towards what was called a ‘system of innovation’ rather than science. In other words, the feeling was – and all the White Papers expressed this – to embark on that research which will be useful to industry and therefore to the economy as a whole. So that was...
the third shift that occurred, to say ‘move money away from pure research towards applied research.’

A concluding perception was expressed as follows:

So we have had those three cascading effects since the start of the scheme [the rating of scientists] in the ’80s, which have led to numerous good pure researchers now getting very small amounts of money...So the top pure research guys, some are disillusioned with the NRF, some are disillusioned and angry and some are merely disillusioned, and most of them have just swallowed their unhappiness and said ‘we will take anything you give us’.

Further debate is, I think, needed as to whether, and to what extent, this professor is correct about these trends and their impacts over more than a decade, at least up to the time of this interview in 2000. In addition, in Part 3 it will be noted that in the last few years, there have been some shifts (linked partly to a post-2003 revised NRF rating system) towards a better appreciation of the national need for PBR and its links also to UIBR. Nonetheless, what is important is that a sizeable section of pure basic researchers such as Prof. Science believed that this was so, and they felt disillusioned because of it.8 There thus needs to be a debate in particular about the role given to fundamental research – both PBR and UIBR – by intellectuals and policy-makers located within our national research system; this itself should be linked to a much-needed debate about the ideas and directions underpinning policies which have emerged since the mid-1990s (see the Introduction to Part 2) relating to the NSI.

Early 2007: Revisiting the virtual unit structure around Prof. Science

During the years after 2000, I was aware, through informal contact, that Prof. Science seemed to be continuing his research just as before. Finally, at the beginning of 2007, a follow-up interview was organised, to investigate how things had developed and changed.9

My interview started with extensive discussion about the developments in Prof. Science’s discipline across the universities of South Africa, and of how attempts to develop vibrant departments in this discipline at certain historically black universities had faced considerable difficulties. Moreover, with at least four white male senior professors in Prof. Science’s own department due for retirement over the next decade, the future of this relatively strong department was itself in question.

I brought the discussion around to the structure of Prof. Science’s own research group. I drew a circle, which I designated ‘X’, on the page in front of us, to represent his research group in 2000, and asked him to recall how many were inside this circle helping with the research. Prof. Science said there were two PhDs and one master’s student. I then drew a similar circle ‘Y’ alongside, for 2007, and asked, ‘How many now?’ Prof. Science said that, besides himself, there were also two PhDs and one master’s student – the same number, but now different students. As in 2000, there
were no post-docs because of difficulties in funding and retaining people after their
doctorates. When I asked what had changed, he said:

Nothing has changed how I work: draw a straight line from circle X of 2000
here on your page to the circle Y of 2007; the line goes horizontally across
the page between the circles [i.e. neither on an incline nor a decline], it's a
straight line graph; and my group works because it's small, me and my few
thesis students.

In 2000, Prof. Science was collaborating with one or two colleagues in the Cape Town
area. In 2007, he was still linked to a few professors who jointly shared expensive
laboratory equipment for their empirically based research projects. In particular, two
of these professors were co-supervisors of his two doctoral students in 2007, because
'we can get NRF funding for these students through our co-supervision, linked also
to our work with this expensive equipment which is government priority funded'. In
addition, Prof. Science was collaborating with a few other international colleagues,
in particular with one or two from a USA-based university lab where he had spent a
sabbatical shortly before the 2000 interview. As in 2000, too, he was publishing in the
few international journals which carried research articles of peers and collaborators
working in this specific subfield. In other words, some of his PBR work was carried
out in an informal international 'network' with other professor-PIs, themselves
linked to an international set of journals in their subfield.

There was one small change, however: Prof. Science was no longer fulfilling the
duty of head of department, which he had been doing in 2000. But some of his
important university-wide senior committee involvements, and also his significant
undergraduate teaching commitments, had continued – also, so to speak, in a
'straight horizontal line'. The interview thus revealed a departmentally based
researcher who combined his basic research mission with considerable teaching
and also university administration duties, in other words, what I have termed a
traditional researcher-lecturer.

Prof. Science, with his 'virtual unit' of a few master's and PhD students, and in loose
collaboration with one or two professors both in the Cape Town area and overseas,
had thus continued with hardly any structural change in terms of the Model T of
PBR across the seven years 2000–07. This illustrates the remarkable resilience and
strength of the main elements of this 'little science' organisational form, focused on
a PI whose formal role was that of a researcher-lecturer in an academic department.
The robustness of this form will be proven many times over as the stories of some of
the 10 other case studies unfold, where it often provides the internal building blocks
for larger research centres and networks.

Concluding summary

I have called the Model T organisational structure a 'virtual research unit' because,
as the interviews with Prof. Science make clear, its incumbents do not view it
as a formally constituted unit: they generally refer to it as ‘my research group’ or ‘my lab’. Nonetheless, it has been shown that this type of grouping does have a recognisable internal organisational structure; it is generally located within a traditional nineteenth-century-based academic department-cum-discipline; and it is oriented towards the production of peer-reviewed publications, primarily in international journals.

The interview with Prof. Science in 2007 showed how this essential internal organisational structure was still robustly retained. In the 10 cases that follow, it will be seen that this traditional structure does not entirely disappear when UIBR and PAR are pursued by research groupings in a university (or university of technology). It will be seen, moreover, how at times such a virtual unit within centres and networks serves to weaken or reconfigure or even destroy some groupings, especially those seeking to form a new ‘real research centre’ structure, built around a larger grouping, comprising a director and subgroups, each headed by a senior researcher (not a researcher-lecturer).

This last point is graphically illustrated in the next case study, Case 1. Of all the 10 research groupings investigated in 2000, this centre displayed most clearly a strong and novel ‘centre-type’ development in terms of its internal structure. But, as will be seen, by 2005 some of the tenacity of the traditional elements pertaining to Case 0 had reasserted themselves within Case 1 – as if the historical components of the first academic transformation could not let go of the present!

Case 1: Model A, use-oriented research, exemplified by the Agriculture Centre

This case deals with a research grouping at one of the relatively research-intensive universities of the Western Cape, which will be referred to as the ‘Agriculture Centre’ or simply the ‘Centre’. At the time of the first interviews, the Agriculture Centre had a formalised internal structure, recognised by the university and by the research grouping itself – unlike the Science Virtual Unit considered in Case 0, which was unrecognised as a unit even by its own Prof. Science. Hence this agriculture research grouping is referred to as a ‘New (Real) Centre’ in the narrative of the case study (‘new’ in relation to the ‘traditional’ model that arose during the first academic transformation, and exemplified in Case 0).

At the time of the first phase of interviews in 2000, the Agriculture Centre was operating as an independent research unit; it had a full-time permanent academic director, whose salary was sponsored by its agri-sector industry which was embedded in the local region in which the (research-intensive) university that housed the Centre was located. In 2000 only about 5 per cent of the costs of the Centre were borne by its university – almost all the rest was provided by the ‘Agri-Sector Industry Network’. The lack of certainty as to whether this region’s agri-sector industry would continue to bear nearly all of the Centre’s research costs was one important factor that led to its re-linking with an academic department in the university’s Faculty
of Agriculture after 2000. This resulted in a new structure, officially termed the ‘[Academic] Department–Research Centre’ structure, by the time the second phase of interviews began late in 2004. In the sections below, I first examine how the Agriculture Centre located itself in the university’s Faculty of Agriculture in 2000, independent of any academic department, before considering the restructuring which, by 2005, had created the Department–Centre entity.

Emergence of a new (real) structure: The Agriculture Centre in 2000

To view the underlying dynamics of the Agriculture Centre, it is useful to begin with an outline of the internal structure of this research grouping in 2000, about five years after its inception in the mid-1990s. Figure 4.2, produced by the Agriculture Centre in 2000, provides an outline of its internal structure at that time.

**Figure 4.2 Personnel structure of the Agriculture Centre in 2000**

**Director of the Agriculture Centre: The research programme leader in 2000**

In 2000, the director’s central role was conceptualised as ‘research programme’ leader for the two major use-oriented research sub-programmes of the Agriculture Centre: one on plant improvement and one on chemical improvement of the agricultural product – both with a significant biotechnology research component. From the interview excerpts below, it is clear that this director conceived of his identity as a full-time research leader, although he also greatly valued his participation in the Agriculture Centre’s own interdisciplinary postgraduate programme focused on
this agri-sector (with honours, master’s and doctoral qualifications), with respect to teaching and thesis supervision. Crucially, therefore, unlike Prof. Science of Case 0, Prof. Agriculture did not need to fulfil academic departmental management functions and, most importantly, undergraduate teaching duties arose only on an occasional invitation-lecture basis.

Experienced senior researchers as leaders of research subgroups

The Centre employed four senior researchers immediately below the level of director, and above the level of the six post-docs. In 2000, three of these held formal posts as senior lecturers, with teaching duties within the academic department with which they were linked. The fourth person was designated a senior researcher because he had no undergraduate teaching duties within the academic department but, in addition to his research work, served as general manager of the Agriculture Centre’s postgraduate laboratories associated with the department.

Because of the crucial role that this layer of senior researchers plays in a research centre such as the Agriculture Centre, this category or position is sometimes referred to in my study as ‘associate professor-researcher’, because this is, effectively, the scholarly status of this level within an HEI.16

The central function of these four senior researchers, each of whom had previously attained their doctorate under supervision of the director, Prof. Agriculture, was as research project leader for one or more research subgroups or teams (Figure 4.3). These teams comprised post-docs and doctoral and master’s students, whose theses were linked to a research project of their team.

Figure 4.3 Research (biotechnology) sub-programmes of the Agriculture Centre
In 2000, only one of the Agriculture Centre's senior researchers was funded by the university; the other three were fully funded by the Agri-Sector Industry Network, which also contributed most of the funds for the six post-docs, as well as providing scholarships for the approximately 70 postgraduates (Figure 4.4).

Figure 4.4 Funding of salaries of the Agriculture Centre, c. 2000/01

Thus, this new (real) centre consisted of a solid core of about 10 full-time researchers (one director, four seniors, six post-docs), supported by about 70 postgraduates acting as research assistants within the various subgroups (teams). More than any of the other use-oriented cases which follow, the Agriculture Centre’s research-productive capacity – and its reproductivity through the training of future researchers – seemed to be well secured by the separation from any department of both its internal structure and its funding, at least as it appeared in 2000.

Administrative-technical infrastructure within the Agriculture Centre

The research personnel structure of the Agriculture Centre was further complemented, primarily through the Industry Network funding, by a group of technical assistants (four technicians specifically for the Agriculture Centre labs, and a few other general assistants), and three administrative personnel (Figure 4.2). There was also a personal assistant to the director, whose post was funded by the university. All the technical and administrative personnel held at least a three-year higher education qualification. There thus existed a highly trained infrastructure based within the Agriculture Centre, outside of any academic department and funded primarily from outside sources, providing the centre with solid support.

The contrast is sharp with Case 0 where, within Prof. Science’s small, departmentally based, traditional virtual unit, there was neither any administrative-technical infrastructure nor any layer of senior researchers below the research head. We can observe here the new model type of research organisation, Model A, which, as I argued in Part 1, is linked to the emergent third capitalist industrial revolution described (here with specific focus on new biotechnology components); in this Western Cape context it is associated with an increasing thrust towards the global economic competitiveness of the regional agri-sector industry from the 1990s onwards. In the next section, we see the director of the Agriculture Centre explicitly spelling out the influence of this regional agri-sector drive towards international competitiveness in his approach to the construction of a Model A-type centre.
Origin and consolidation of a new (real) centre

In 2000, two interviews were undertaken with the director of the Agriculture Centre. These provided much of the information about its origin in the mid-1990s and its consolidation during the following five years (before the significant changes, mentioned above, that were due in part to the departure by 2005 of both the director and a senior researcher).

Here I outline some special factors shaping the Agriculture Centre’s development up to the first phase of interviews in 2000, when the internal personnel structure just described had been consolidated and seemed quite solid. These factors acted as an especially solid glue for the Centre; they cannot necessarily be expected to come together in this positive way for other centres or CoEs which are emerging across South African universities. The consolidation of the Agriculture Centre was, in certain ways, unique.

Unplanned origin of the research centre

The Agriculture Centre originated largely by chance in the mid-1990s. A set of factors seemed to coalesce; its establishment was not due to any new research policies on the part of the national government, nor any clear design of its own university institution. But a clear underlying factor supporting the establishment of the Centre was the need of the local agri-sector industry to attain international technological competitiveness.

The Agriculture Centre’s accidental origin, in the sociological sense, emerges from the story outlined in the first interview with the director. He discussed the situation in the early 1990s of an allied academic department in his Faculty of Agriculture, to which the new Centre eventually became linked:

…the only place [in South Africa] you can obtain a degree in [subfield of agriculture, the focus of this allied academic department’s work] is from the [name of his university]…That was quite an old department. I [on the other hand] was always associated with the Department of Microbiology. When the Professor of [allied academic department] retired in the early ’90s, the [agri-sector] industry found themselves in a position where they couldn’t replace him…At that time the [agri-sector] industry also realised that they needed a very solid technology infrastructure if they really wanted to tackle the export markets [i.e. with the demise of apartheid by 1994]. At that time they approached me and I said, ‘No, I am not a [specialist in the area of the retiring professor]…but what I can do is try and develop a plan which you can consider and then look for somebody who would fit such a plan’…[but] there were none; they tried to recruit people from overseas, there was nobody available – it is not only a typical South African problem, it is a problem in the world. People in [the specialism of the retiring professor] take on jobs in industry; they don’t stay at universities. In particular, the South African position was very dire.
According to another interviewee, the vice-chancellor of the university, together with some leading agri-sector industrialists of the region, ‘virtually pulled this A-rated microbiologist [i.e. the man who would become Prof. Agriculture] off the plane’ after he had already decided to head up a gene technology research centre abroad – ‘and offered him a position full of possibilities, as director of the proposed, independent institute [research centre], holding a well-paid, newly created chair’. This microbiologist was ideal in many ways: besides his A-rating in basic science with over a decade of publications in plant genetics (following a doctorate abroad), he had grown up on a farm in another province; he had many years of experience of how research and universities worked; and he had a growing interest in use-oriented research for the agricultural industry and national economic development.

Moreover, this microbiology professor had friendship networks with some of the leading industrialists of this agri-sector, who frequently were alumni of the university (although he commented in the interview that it also helped that he was seen as an ‘outsider’, as someone from another province and not historically embroiled in this region’s inter-family farming and social networks). He thus agreed to accept the position of director of the new Agriculture Centre but only, as he put it in his interview, if three conditions were met.

The first condition stipulated by the new director was that the agri-sector industry within the region come up with its own 20-year plan for industrial innovation and development, to link with his overall research biotechnology programme to be initiated in the proposed new Agriculture Centre:

Then I said, ‘I will consider it [the directorship] if the [agri-sector] industry has a plan. It is now a plan at university level, but the university option won’t be successful if the industry doesn’t come up with their own plan.’ That was in 1995. The export markets looked fantastic but the technology infrastructure to support such a sustainable effort was not really in place…they gave me a firm undertaking that they would do it…They said they would do it in two pieces: (1) in a five-year term and then (2) a twenty-year term. The five-year term started on 1 January 1996, to [the] end of 2000. Before the year 2000, they undertook to have a long-term plan for 20 years.

In fact, by 1999 the agri-sector industry had come up with a clear long-term strategy – a ‘Vision 2020’ – focusing on three specific quality products within this agri-sector, all with an eye out for economic competitiveness. Most importantly, as the director stated clearly in the interview, with such an industry 20-year plan his Agriculture Centre could productively design most of their research to fit within this framework. This would eventually crystallise in terms of the two core biotechnology research sub-programmes of the Agriculture Centre in 2000, namely plant improvements and chemical improvement of some of the products, respectively.

I would argue that this research was essentially UIBR – rooted in basic research over a number of years, not too tightly constrained by immediate results, but always with an eye on how it could fit in with the 20-year agri-sector industry priorities just
noted. The idea of basic research with ‘use-inspiration’ (i.e. UIBR) is reflected in an interesting set of comments during this interview with the director:

…because there are the growth objectives [linked to the industry’s long-term plan], although your [research] project is assessed on a yearly basis, the priority doesn’t change. If they [the agri-sector industry] have identified, say, for instance, the development of new yeast strains that will reduce the levels of sulphur dioxide in [a product] as a priority, they commit themselves to that priority. If the project runs through five years or even ten years the priority will not change…The priorities are clearly defined. We know what kind of projects to think about in order to realise those growth objectives and that is your security. The only thing that can be a stumbling block is your own lack of progress. That helps a lot because many industries worldwide and many companies – if you collaborate with industrial partners – the problem is priorities change from one year to another. That is why you can never plan a long-term [research] project where you can really make an impact. But with the [Agri-Sector Industry Network] structuring [the funding linked to the twenty-year plan] one can do that.

This demand by the director of the Agriculture Centre for a 20-year industry vision, and its acceptance by the agri-sector industry leaders, gave the research centre enormous security at this time in terms of its pursuit of UIBR – more security than was found at any time for any of the other nine use-oriented research groupings.

The second condition stressed by the new director was that the agri-sector industry of the region, in conjunction with his university and other (non-university) locally based research institutions (Figure 4.5), should develop a structure for the funding of R&D needed by this industry:

…I said ‘Once the industry has a long-term plan, then we need a network of everybody and all the institutions that can realise those growth objectives’ – and that was the birth of [name of Agri-Sector Industry Network].

This professor insisted, therefore, that there should be an I-U research partnership structure which could fund R&D, so that the industry could become internationally competitive. Out of this, the Agri-Sector Industry Network was born, following a few years of negotiation after the mid-1990s in which the director of the Agriculture Centre and some leading local industrialists played important roles. Here, too, some special factors linked to this local agricultural region were significant: some of the industrialists held postgraduate degrees (some in agricultural science), including the head of a leading company with a PhD in engineering who was strongly associated with the vision of the Agriculture Centre director. The director himself was to comment in the interview: ‘I would not [otherwise] have been able to convince the [agri-sector] industry…it was only because we had really fantastic leadership at that time in the industry.’ Furthermore, the vice-chancellor of the university played a personal role in these negotiations.19
The essentials of the Agri-Sector Industry Network structure, which was still functioning in a similar way during the second phase of interviews at the end of 2004, were as follows:\textsuperscript{20}

- Funding for Industry Network research projects came primarily from a levy imposed at point of sale, by the agri-sector industry on its own members, on a range of its agricultural products, as well as from a special business company that had been set up to provide further support.

- Any researcher or research grouping could submit research proposals for funding, but projects had to link directly to the Industry Network’s long-term research priorities. A short ‘Concept Project Proposal’ had to be submitted by May of a given year, and if this passed the first hurdle of committee scrutiny, a full ‘Project Application’ had to be submitted in August, leading to a final decision in November. Thus, a fully-fledged system of competitive evaluation of research proposals was established.

- Research project proposals were considered by relevant technical committees (Figure 4.5), which over time had developed a series of subcommittees to view specific research proposals. Representatives from different subsector industries and allied industry stakeholder groups made up 80 per cent of these committees, which meant that the nature and direction of research funding was dictated primarily by industry, not by academia. In addition, expert subcommittees had emerged (e.g. plant biotechnology, packaging and distribution), drawing in academics and other specialists to provide advice on research feasibility, quality, capacity and so on to the various technical committees and their subcommittees.

- Figure 4.5 shows that any researcher in the country (‘Other’ in the bottom row of the figure) could apply for relevant funding. In the mid-1990s when the Agriculture Centre was established, it received an initial grant of about R10 million from the agri-sector industry, with a requirement that the university provide another R5 million.\textsuperscript{21} By 2004, only about one-third of the Agriculture Centre funding was derived from the Industry Network, but in the 1990s its
input was crucial. According to the 2003 annual report of the Network, only around 30 per cent of its overall R&D funding went to this university (across a number of research groups and researchers), compared to over 60 per cent for the Agricultural Research Council (ARC) research grouping based in the region (Figure 4.5). Interestingly, since the ARC focused more on PAR work (compared to the UIBR of the Agriculture Centre), these funding percentages also reveal that the Industry Network was oriented especially towards directly applied research. This was confirmed in the 2004 interview with its executive director, who stated that ‘we must give money across the value chain’, adding that ‘only about 15 per cent of our research funds are possible to put in a basic area of research like the microbiology of [the Agriculture Centre]’.

Clearly, therefore, the Industry Network was a novel and innovative network linking agri-sector industry and university research, and providing competitive research funding – including for UIBR – to a wide range of research groupings (including even researchers based in laboratories within industry). Moreover, it was expected that funds would be allocated, as part of the ‘second condition’ envisaged by the Agriculture Centre director as early as 1995, ‘for the good of the industry as a whole’, not for the benefit of any specific section or company in this industry. During the period of interviews, this principle seems to have been applied consistently through the system of technical committees and subcommittees.

The third condition stipulated by the new director was viewed as equally important in 2000, though by 2004 the situation had changed significantly (see below). This condition was that the Agriculture Centre be located within the Faculty of Agriculture at the university, but not inside any one academic department, including the department with which it became linked. As he said in the interview in 2000:

When I developed the plan [in the mid-1990s], I said, ‘One has to put something next to the [academic department];’ so the benefit of that is… first of all you don't have to rely on the very limited pool of undergraduate students [from this specific academic department] who all get fantastic jobs in industry... [And secondly] if you have a separate institute or centre or division then you can open it up, so you can have a multidisciplinary forum for people doing microbiological research, genetics, biochemistry, chemistry, but focused on problems of the [agri-sector] industry... [Moreover, there can be recruitment of undergraduates] who might not have known that there is something like a career in the [agri-sector] industry, say for instance a student doing agriculture at the University of Pretoria or Zululand or the University of the North or the Orange Free State... The third benefit is... having a separate structure, you don’t threaten anybody... so [the Agriculture Centre] would be a new structure and you could start fresh. You can appoint people on merit, people that you know – energetic and productive and one would also go for younger people... That was the plan...
This director was consciously theorising about ways in which a department-independent research centre could relate to other departments and disciplines within the university. He also theorised about how a division of labour might work between the three locally based research entities involved: he argued specifically that his Agriculture Centre could focus on the fundamental side of the research spectrum; the ARC research grouping in the region could focus on directly applied research; and the nearby Agricultural College could concentrate on transferring knowledge to interested farmers. The director's thinking, and his efforts to facilitate such a 'division of research labour' in the local agricultural region after 1995, are captured in Figure 4.6 (which was prepared in about 2000, based on a slide presentation). With reference to the discussion of Stokes's concepts of UIBR and PAR in Part 1, this diagram locates the Agriculture Centre quite close to Pasteur's Quadrant of UIBR, with the ARC research grouping close to PAR (while the Agricultural College would fall into the category of 'transmission' of knowledge to the farmers).

Moreover, while he himself was an A-rated scientist with a focus on what he termed ‘fundamental research publications’ in plant biogenetics, the director was acutely aware of the complex knowledge processes needed in agriculture, and the need to enable UIBR (not, however, the director's term) effectively to reach the farmer on site. At one point in the interview, he touched on the need to introduce new methods of technology, including biotechnology, to experienced farmers:
It is fine to say that we have been making this [agri-sector product] on a family estate for the last century and we have always had a good market for our product. If you tell them, ‘Have you looked at the market? Have you looked at the competition globally especially now that the market has opened up either way for South Africa?’ it’s quite a different ball game and the only way to remain competitive if such an estate is already competitive, is to be ahead when it comes to technology.

And later, he directly stressed the need to understand the farmer’s frame of reference: ‘You should always put yourself into the shoes of the farmer and think how they see it and talk to them in such a way.’

To facilitate this ‘chain’ from UIBR to farmer, the Agriculture Centre continued, right up to the 2007 interviews, to publish in local farmer magazines; Centre researchers also ran workshops and seminars for agriculturalists, and sometimes visited farm production sites.

Nonetheless, although the Agriculture Centre took care to ‘connect’ to the farmers, from its beginnings it was firmly rooted in basic research, around molecular biology in particular. One of the senior researchers interviewed in 2000 said:

Since we are working with [postgraduate] students we try to balance basic and applied research. Within the needs of industry we are trying to find a niche where we can do both. You can’t just do applied. It will be shallow. It needs fundamental studies to boost the other side.

Linked to this, however, was another important insight by the director of 2000, that, even at the relatively elite South African university where he was based, the ‘undergraduateness’ of all universities in South Africa pervades the corridors and halls and often makes world-class research difficult: ‘But to transform a specific environment [at his university] from a teaching environment to a research environment is the major goal. It soaks up so much energy you won’t believe it.’

In summary, therefore, by locating the Agriculture Centre in a faculty but not a department (with significant undergraduate teaching), the director hoped to achieve a powerful focus on research by all within the Centre; at the same time, he sought to develop links and synergies between his UIBR-oriented research centre and a wide range of other academic departments at his university, as well as with a wide range of PAR groupings outside of the university; and to pursue modes of engaged scholarship with the farming community of the region.

The role of academic leadership within a new structure such as the Agriculture Centre

This section argues that the role of director of a larger, internally complex research grouping such as the Agriculture Centre encompasses vital tasks, additional to and in some respects different from those of a PI (such as Prof. Science of Case 0). In Case 1,
these additional leadership tasks related firstly to the internal structure of the Agriculture Centre, with particular reference to the layer of ‘associate professor-researchers’.

The director as overall programme leader of research

A core difference between the Agriculture Centre’s internal structure and the earlier small unit structure of Prof. Science’s grouping is that the Centre was set up as a genuinely collective entity under the direction of its programme leader or director, in terms of both the overall thrust of the research programme as well as the decisions about funding for research and how these funds were allocated.\textsuperscript{25}

Not only did the Agri-Sector Industry Network, and particularly its technical committees (which reviewed project proposals for funding), have significant influence over the overall direction of the research via the support for projects, but the director himself had significant control over all of the Centre’s projects, including those of the senior researchers who acted as project leaders of the subgroups or teams. Moreover, the director sought to ensure his control over the funds, in accordance with the mission of the Agriculture Centre – itself shaped by the Industry Network.

This is important, particularly given the fact that in 2000 most of these seniors in the Agriculture Centre also held positions as senior lecturers (with later promotions to associate professor for some) in the academic department to which they were linked. In contrast, Prof. Science of Case 0 described how one or two senior academic colleagues in the department collaborated with him, and even sometimes shared part of the funding and a laboratory, but were essentially autonomous: they controlled their own core funds, their PhDs and post-docs, and also the important decisions about the directions for research of their respective ‘traditional units’.

In the Agriculture Centre case, however, although the senior researchers had senior lecturer status and were experienced researchers, and although they each headed their own research subgroups with considerable autonomy, in the last analysis they fell under the control of the director (programme leader) in terms of the overall direction of the Agriculture Centre’s research programme. In 2000 most of these senior researchers, as well as all the other post-docs and postgraduates within their subgroups, were dependent on the Industry Network funding for their positions.\textsuperscript{26}

In relation to some case studies described later, the overall research mission and direction of the Agriculture Centre will also be seen to be stronger than in other research groupings (for instance, in Cases 8, 9, 10) where it seemed there was a ‘centre’, but further analysis suggested that it was rather a ‘virtual centre’ or ‘agglomeration of professors’, with far less overall common direction in relation to the senior researchers who made up the grouping.

Admittedly, the issue of funding control and overall research programme control was complex – even at times ambiguous – for the senior researchers in the Agriculture Centre (i.e. for what I have termed the ‘associate professor-researchers’). This
complexity and the potential negotiability of the situation were captured in this comment by the director, when probed about it during his interview in 2000:

Director: In this [Centre], the four people that I talked about [senior researchers] – I define my role as the programme leader and they are the project leaders. For the programme it means that I decide because of my interaction with industry, because what I see overseas [for example] with my interaction with the OID [an international agency] – I say, ‘There must be a priority that we make our [name of agri-sector products] free of chemical preservatives.’

Interviewer: So it is like an overall direction that you give?

Director: Yes. That is the direction. I think, say, one of the projects that we can do is to develop a yeast that will have the capability of yoghurt bacteria...What will we learn from the yoghurt bacteria which we can put into the [agri-sector] industry?...Then I target one of the project leaders and say, ‘This idea falls into your court. Come up with a proposal’...We will discuss it as a unit together. We always work together. It is not only me and one of the project leaders. I will come up with the idea. Everybody will listen to it. Then I will decide whether this project leader must develop it further. From then when the proposal comes back we discuss it, we develop it further, we read up more and the whole team participates in that and then eventually, when we see this is a project proposal, then I take it to [name of Industry Network] and say, ‘This I think is a priority. This is the project we can do to fulfil that. Does it fall into what you would regard as a priority for funding?’ If they fund it, we accept students [i.e. master’s and doctoral thesis students, to link up with the research].

Such a situation might work well if there were strong respect for the leader (in this case, there were close academic, social and language ties, including the fact that the director had previously been a PhD mentor and supervisor for most of these seniors), and it can be enhanced when good academic relations exist across the core team of senior researchers. But it also has the potential for creating situations of conflict – as will be seen not only for the Agriculture Centre, but also in certain other cases analysed later.

Academic leadership, not only management

A further dimension of this Model A-type centre leadership role, often poorly understood by research groupings and their universities, is the fact that leadership of such a large, complex grouping is not simply one of ‘management’; it requires a full-time, professorial-level director with wide academic experience and security of tenure to achieve these tasks. A number of comments made during his interview in 2000 by the director of the Agriculture Centre illustrate this idea:
[It is not possible to] sit back and become an efficient administrator. To me that is not leadership. To me that is a good manager. I never wanted to be a manager. A leader means that you lead academically, you lead people to be innovative and your research programme is always dynamic, always developing, always making progress but at the same time also your interaction with the industry and your collaboration also keeps on developing and lifting up. You can always improve things.

Innovative and time-consuming leadership and networking tasks on the part of such an academic director were needed not only within the research centre itself, but equally importantly in relation to the adjoining academic department and the faculty as a whole, as well as to other HEIs and even international agencies:

I don't have to show student numbers on my own [Centre] books, the funding for myself and [the Agriculture Centre] come[s] from the industry on a competitive project basis…the [Centre postgraduate] students count on their books [i.e. count as student FTEs for the adjoining academic department]. So they [the academic department] get new positions [lectureships] in addition to what they have and that has already happened…There are three [new] positions. In total there were only three people [in the old academic department], now there are six…[Moreover] when we started it was myself and then somebody with a PhD, and a secretary. I had to find the money for them. We were three. By using this model there are [now] five people with PhDs and two secretaries. I now have two cleaners. We have 55 postgraduate students [in mid-2000]…

[Moreover] it doesn't work to think ‘if [name of his university] is fine then you are hunky dory’. Not true. You have to help other institutions. We are linked to Rhodes University, to the University of Durban Westville, to the University of the Free State, and sometimes it is also not because you want to help, it is also sometimes you are looking for help…

Then I have a third role and that has to do with the image of the [agri-sector] industry internationally. There is an international office for [the agri-sector in Europe]…I am in one of those expert groups. I am one of the delegates of South Africa…Because I have a seat on that level, it helps to protect the interests of the industry…

Sometimes you must also have the bigger picture and say, ‘What is going on at the University of the North?’ – or, for that matter, at the University of Adelaide or at the University of California – and to be able to stand back and say, ‘This is the picture. This is what we can do. They are too far ahead, we can’t start yet’ or to approach people abroad and say, ‘We would like to collaborate with you on this and this and this.’
Thus, a crucial set of academic leadership tasks fell to the director of this Model A structure, involving developing new goals and missions, strategising, innovating, networking, coordinating, etc. And not to be forgotten was the vital role of the director in planning and providing for a new generation of researchers, if a centre such as this were to survive over time:

...I try to play a positive role in succession planning so that we don't end up in a situation where we were – where we couldn't replace the professor [of the old department in 1995]. We have identified potentially dangerous areas. And if we were not able, for instance, to train people immediately at the level of PhD to do a doctoral degree in [agri-sector linked] chemistry, I suggested that we get good bursaries for hand-picked students and send them to the best places in the world, and that happened. We had one person at the University of Adelaide, who did a PhD in [such] chemistry. We also sent somebody to the University of California at Davis...My definition of success is if you can be replaced by one of your own products who would be better than you – that is success. So often, it happens that you have a very good professor who is really top-notch but when he retires, there is nothing else. If somebody doesn't miss you when you take another position or you leave or you die or retire, then you are successful.

Internal restructuring of the Agriculture Centre by the end of 2004

The last comment by the director, made in 2000, about succession planning, described a situation that became a reality a few years later.

In late 2004, I undertook the second phase of interviews to track the changes in the Agriculture Centre. I found that the most senior researcher of the Centre, whose salary was fully supported by the Industry Network, had left, soon after the 2000 interviews, to take up a research management position within a major agri-sector industry company in the region. It seems he was offered ‘a much higher salary than anything he could be offered at the university’; another factor mentioned was that at least he would now have more time for his family outside ‘normal hours’.28 He nonetheless still held an official Affiliated Associate Professorship within the Agriculture Centre, did some lecturing on the Centre’s postgraduate programme, and linked some of his industry laboratory projects to Centre projects as well. My interviews also revealed that the director had left the Agriculture Centre in 2003 to take up a research post abroad, although he too retained a position as Affiliated Associate Professor.29

A new combination structure: The Academic Department–Agriculture Centre

According to the second-phase interviews with some of the other senior researchers at the Agriculture Centre, they would have been faced with an insecure situation if an unknown new director had taken the vacant chair. In addition, the Agri-Sector
Industry Network had been pressurising the university to take more responsibility for funding the Agriculture Centre itself, particularly since it was felt that there was a limit to the more basic research funding available from the Industry Network. There had also been worries that some of the Agriculture Centre's invested capital for salaries was being used up faster than had been expected. Moreover, both the Industry Network and the university were concerned about the long-term development of the academic department itself, and about how this was affecting the training of students for the industry. They had even suggested, before the departure of the Centre director, that he take up the headship of the academic department as well.

In this situation, the remaining senior researchers of the Agriculture Centre agreed on a complete structural change. They would move into the academic department, with their salaries now carried by the university (except for one senior researcher who was still paid from Industry Network funds). The situation in early 2005 is illustrated in Figure 4.7. What was termed the 'functional structure' of the Academic Department–Agriculture Centre (AD–AC) formally operated as follows:

- The five senior researchers from the Agriculture Centre were located alongside the five lecturing staff of the (old) academic department, comprising what was termed the 'Management Team of the AD–AC' (i.e. second row from bottom). In Figure 4.7, the five Agriculture Centre researchers are shown on the left, with their respective research teams below.
- In terms of lecturing duties, most of the previous academic department staff had been appointed at lecturer level and were still completing their doctorates. The sole professor is shown on the far right of Figure 4.7, with his own research team. These academics still undertook a considerable amount of the departmental undergraduate teaching, while the five Agriculture Centre researchers continued to drive the postgraduate programmes linked to the agri-sector biotechnology, while also undertaking limited undergraduate teaching. (Two of them had been promoted to associate professor level, as shown in Figure 4.7.)
- One of the associate professors from the Agriculture Centre was now chairperson of the academic department, with this position to be rotated among senior staff every three years, and some of the departmental academic administrative work parcelled out among the management team of academics.
- Each senior researcher continued to be a project leader for his or her research team, although the subgroups of the two associate professors were larger. Each team included at least two post-docs and some departmentally based technical officers.

Another important change was observed during this second phase of interviews: as mentioned above, by this time only one-third of research funding was derived from the Industry Network. However, other sector industries were now making significant contributions (for example, companies based in yeast manufacture) and, importantly, more funds were derived from THRIP and the national government's recently established BRIC scheme.
Figure 4.7 Structure of the Academic Department–Agriculture Centre, early 2005

An administrative hub of research, finance and administrative managers, connected to BRIC funding, was being constructed in early 2005 within the AD–AC combined structure. These managers were expected to provide administrative coordination for the research work of the new structure (assisted by about eight administrative and 10 technical assistants), and to drive the commercialisation of research expected by the BRIC scheme. The research manager of the AD–AC had been an Agriculture Centre post-doc, later studying for an MBA, and it was planned that this person would assist a business manager to grow a spin-off company in biotechnology, linked to the Agriculture Centre through the BRIC funding. Clearly, therefore, the kinds of U–I linkages described in Part 1 as associated with a global second academic transformation, including spin-off companies and commercialisation of research, were alive in these developments.

Interestingly, it was stressed by some of the senior researchers during the second-phase interviews that, except for the BRIC funding – itself linked to a new emphasis on the Agriculture Centre ‘as an innovation generator’ associated with this funding – ‘nothing [had] really changed’. To some extent, I would agree. However, I suggest that the following were probable future areas of tension with respect to the new functional structure:
The senior researchers of the Agriculture Centre had, by early 2005, attained more security as tenured, department-based academics funded (mostly) by the university itself. But what might now prevent a slow drift by them into more and more undergraduate teaching, especially if university finances became tighter? The previous structure established by the director of 2000, ‘outside but alongside’ a department, was specifically designed to minimise such a drift.

It was hoped that, by rotating the departmental chair every three years, and sharing much of the administration across the academic management team, more time would be secured for the Agriculture Centre researchers, especially the associate professors. But would they actually get this time in future years?

What of the self-identity of the senior researchers in the Agriculture Centre? Might their self-definition not alter over time, especially if calls arose for them to become more involved in departmental teaching and in university committees and duties? Might there not be a shift towards an identity of researcher-lecturer, with these seniors – whose work had previously been almost entirely research-oriented – thus becoming more like traditional Prof. Science of Case 0? Or might the shift be in the other direction, linked to work with a spin-off company, and leading to different tensions between UIBR and consulting-type research activities?

There was now no clearly separate ‘director’ at the head of a research centre, and each senior researcher in the combined AD–AC structure to some extent now controlled funds for each of their research teams. Might this not mean that the research centre direction – which had encompassed a common programme in 2000 – would now become relatively weaker?

Early 2007: An interview with Associate Prof. W

I revisited the Agriculture Centre early in 2007 to see what had changed and what tensions had surfaced, particularly having in mind my questions about the relationships of the Agriculture Centre researchers within the academic department. Some things were as I had predicted at the end of 2004, but there were numerous aspects of the current situation which I had not expected to find.

One issue, that of involvement in undergraduate teaching, had arisen as I had suspected. Most of the senior researchers of the old Agriculture Centre had been drawn into undergraduate teaching to quite a degree, alongside their academic department colleagues. Interestingly, too, one of these senior researchers had just resigned and would soon join his researcher ex-colleague in the same major local agri-sector company. This now-departing Agriculture Centre senior, W (who, it should be noted, had recently been promoted from senior lecturer to associate professor), also planned to retain research and postgraduate teaching links with the Agriculture Centre. While there were clearly a number of factors influencing his departure, including the fact that ‘I have always been attracted to the business side as well as research’ (interview with Associate Prof. W), in addition he commented: ‘Last year I only managed to publish one article…I had two semester-long undergraduate
courses to teach of 14 weeks each...I have lots of department management meetings each month...I sit on five [Industry Network] committees and on some other professional bodies too..."

It also emerged from this interview that another senior researcher of the Agriculture Centre who had been serving as head of department (HoD) of the new AD–AC structure at the end of 2004, was still HoD in 2007 – so the planned rotation of the HoD role had not (yet) happened. However, the management team of all 10 AD–AC senior academics was in operation, and each academic was expected to share some of the administrative tasks. Nonetheless, it was clear that the reality of being in an academic department was impacting – to some extent negatively – on all the senior researchers from the Agriculture Centre.

At the same time, being in a department had provided for some growth and innovation. For example, the biggest surprise of the 2007 visit was finding a substantial hive of research activity within the AD–AC structure. In many ways, the old academic department had been consolidated; by merging with the Agriculture Centre, it had grown in size and quality, and the Faculty of Agriculture was now offering the department sole occupancy of the building in which it was located. The numbers of senior academic staff were beginning to increase; and, although master’s and especially honours student numbers had been slightly reduced, this was by a conscious decision, in order to counter high teaching and supervision loads. As a result of a similar conscious strategy, PhD numbers had nearly doubled, to over 20 in 2005/06, while post-doc numbers had more than doubled since 2005.32 In this way, the research subgroups and teams (Figure 4.7), anchored in PhDs and post-docs, had been expanding in both numbers of researchers and numbers of research projects.

One factor in the post-doc expansion was the fact that researchers in the AD–AC structure had been constructing networks with academics and researchers in allied departments of the university, such as Chemistry and Food Science. This broad-based network had moreover just become the joint recipient of an NRF Research Niche Area award in their agri-sector science subfield for 2007. This would not only consolidate the role played by academics in this university across a number of departments, but also further enhance the AD–AC as an internal research bloc.

Thus, in many ways the move of the Agriculture Centre into a university department, while not without some research negatives (especially teaching-cum-administration loads), also displayed a set of positives, especially in relation to the overall research enterprise. Perhaps the biggest positive, both for the Agriculture Centre and for the academic department, was the expansion of the ‘future spin-off company’ (Figure 4.7) after 2004. The return visit in 2007 showed this company, which I will call ‘UniBiotechnology’, to be flourishing at that time.

The features of this company that embodied the commercialisation of research at the Centre indicate how far this Model A structure had moved beyond that of a ‘traditional’ research-oriented academic unit like Case 0, based on curiosity-oriented research.33 The initial idea had been to grow the shell of a technology innovation
company inside the AD–AC structure for about three years. However, there emerged so many requests from industry for projects in ‘PAR plus routine consultancy’\(^{34}\) that by 2006 UniBiotechnology was formally constituted as a separate company, focusing on the applied side of research, as well as on the commercialisation of technology. It became part of an overall holding company established by the university,\(^ {35}\) with the university, government and some Agriculture Centre researchers having shares in the biotechnology company. Importantly, too, the funding of the Agriculture Centre from the BRIC scheme in the Western Cape greatly helped in the development of the company.

By early 2007, UniBiotechnology not only had a research business manager and four contract researchers (all post-docs), but there were more than 50 administrative and technical staff in the AD–AC structure to cope with the research activities to which it was now linked – with a significant number of the staff contracted within the company itself. In addition, the company had a board of governors (the majority being industry representatives) to oversee financial affairs. On the research side, crucially, the four remaining senior researchers of the Agriculture Centre still provided leadership and supervision for the contract researchers and their groups in their undertaking of research-innovation work linked to the company. Of course, however, this further increased the overall duties of the four seniors.

Funding had in the meantime also been expanding: the Agri-Sector Industry Network now provided less than 30 per cent of all funding, with the NRF and the DST and THRIP, as well as individual companies, having increased their contributions. The university itself also needed to be factored in, since it was bearing significant costs through supporting many academic and non-academic positions, and also providing equipment within the academic department. Overall, therefore, there were clearly exciting developments and much creativity to be observed in the research work of 2007. And the Agriculture Centre, with its focus on UIBR and some PAR, rooted in molecular biology, had created a spin-off company, which in many ways exhibited classic global features of the triple helix of U–I–G research relations around biotechnology – almost exactly as predicted from the international trends discussed in Part 1.

By early 2007 it thus appeared that the academic department had effectively become the hub for all these developments. The remaining Agriculture Centre senior researchers were now all senior members of the department, with two of them having been promoted to full professor.\(^ {36}\) Their research teams of post-docs, postgraduates and technical officers were now located within the department, driving forward the departmental postgraduate programme in agri-sector biotechnology, and undertaking related biotechnology research, especially as UIBR.\(^ {37}\)

Although the Agriculture Centre’s foundation was in UIBR work, outside companies were clearly making increasing demands on the Centre researchers to undertake PAR work (for example, developing a specific yeast strain for a Western Cape industry problem). Interestingly, it emerged from the interview with Associate Prof. W in early 2007 that more and more requests had been coming from companies in
this agri-sector industry for what I have termed ‘routine consultancy’ work – that is, work involving no acquisition of new knowledge and hence ‘non-research’ – in this case routine testing work such as testing yeasts for compliance with international standards for this agri-sector.38

Associate Prof. W also noted that the new demands from industry were leading to an expansion of UniBiotechnology company work, resulting in more contract positions focusing on consultancy and development work within the separately constituted company, which were mainly filled by technical officers or by graduates from the Agriculture Centre postgraduate programme. This expansion could provide some cross-subsidisation for the research work in the AD–AC departmentally based laboratories, but it also raised the issue of the necessary ‘wall’ between university research and industry research (see Introduction to Part 1, and also Case 4 in this chapter). While this was not mentioned as a problem in the interview, it will in the future surely become part of a wider debate about U–I relations with universities in South Africa – as will be argued in Part 3 of this book.

In relation to what I term U–CS links, Associate Prof. W commented that while some roadshows and presentations were still being produced for farmers in their region, as well as popular articles (for instance in the agri-sector magazine cited earlier), the emergence of the UniBiotechnology company – and other departmental academic demands – had led to a fallingoff of the time spent by Agriculture Centre academics on their local farmer and community research connections.39 Thus direct work for industry (the U–I linkage) was substantially increasing relative to previous farmer-local community work (U–CS) – an important issue, which is followed up in Part 3.

Concluding summary

From its origins in the mid-1990s, the Agriculture Centre was constructed – according to the vision of its innovative director – as what I term a ‘new real centre’, which best exemplified my Model A in terms of internal organisational structure. This structure could be observed clearly during the first phase of interviews in 2000: a stand-alone research centre alongside but separate from an allied academic department, with a Centre director in charge of a coherent research programme around which four senior researchers led their respective research subgroups. All research had a clear focus in terms of the overall mission of the Centre – focusing on biotechnology in this agri-sector. The Centre in 2000 also ran its own postgraduate programme linked to this area of focus, comprising about 70 postgraduate students, with an infrastructure of around 10 technical-administrative personnel. An agri-sector industry levy set up by a novel research-financing structure – called here the Agri-Sector Industry Network – meant that the Agriculture Centre was the best-funded of all the 10 use-oriented cases investigated in 2000. Most importantly, as a real centre with an officially designated title and structure, its various research subgroups were locked into the overall mission direction shaped by the director and the principal industry funders.
As noted in discussing the origins of the Agriculture Centre, its centre-type structure emerged in the late 1990s as a response to the global spread of the third capitalist industrial revolution, where its UIBR relating to molecular biology in particular provided its local industry with the hoped-for technological edge needed in a context of intense international economic competition.

However, seven years later its mode of research organisation had altered significantly and it was no longer clearly described by my Model A type. In the context of growing insecurity regarding its agri-sector industry funding, and the loss of two senior staff members, the remaining senior researchers had retreated into a university department based in the Faculty of Agriculture, and now functioned as senior researcher-lecturers. Moreover, the department into which they had moved – rather than the Centre – had emerged as the container for all research activity, with the four Agriculture Centre senior academics and their research groups now effectively a substructure within the department. The Agriculture Centre was now functioning as a centre-in-a-department.

By 2007, too, the combined AD–AC structure had given rise to a separately constituted spin-off company whose focus was on transforming research outputs into biotechnology primarily for the regional agri-sector industry – thereby also enhancing the overall status of the centre-in-a-department.

Negatives in relation to research development were certainly present for the Agriculture Centre in 2007, compared to its stand-alone status of 2000. In particular, its academics, with their new identity as researcher-lecturer, now had to deal on a daily basis with undergraduate lectures, administrative duties and a host of other university-wide commitments. Moreover, the centre-in-a-department now had the potential to fragment into research subgroups, which could become simply a loose network of professors without a common mission (as will be observed for some of the cases in the chapter which follows).

An important set of positives, on the other hand, had also emerged. By 2007, some of the lecturers of the old academic department were linking up with sub-areas of the Agriculture Centre research, and the combined AD–AC structure was attracting good post-docs to join its research subgroups. Some researchers were connecting with researchers in allied departments, forming a wider agri-sector science research network, which had just received NRF Research Niche Area funding. There was also relatively good funding support from BRIC, THRIP, the Agri-Sector Industry Network and other companies, particularly for the PAR side of the work of the Agriculture Centre and the spin-off company. Nonetheless, it should be noted that a study by Wood and Kaplan (2005), which compared research funding of one Australian agri-sector industry with that of the same agri-sector in the Western Cape, pointed to a significantly higher level of funding in Australia. Thus, even though in many ways the Industry Network of Case 1 had provided a lead in academic research funding in South Africa, it still lagged considerably behind with respect to international trends – an issue which is discussed more fully in Part 3 regarding levels of funding of university research in our county in general.
The most interesting of the positive factors is that, despite the increasing demands made on the new spin-off company for PAR and routine consultancy work, all the research activity of the Agriculture Centre was, in 2007, still underpinned by strong UIBR. The senior researchers had not neglected this side of their research work; if anything, their departmental university base after 2004 had perhaps strengthened it. But this high-quality UIBR could continue in 2007 and beyond only if teaching and other departmental duties did not swamp these senior researchers, and if sufficient research funds continued to flow in.

I turn now to a discussion of Case 2, in which ‘Prof. Genes’ organised his UIBR and PAR work successfully during 2000–07 within a much smaller research unit. The fact that this unit was based in a science faculty but outside a department, and linked also for most of this period to a spin-off company outside the university, makes it an interesting comparative study to Case 1.

**Case 2: Model B, use-oriented research, exemplified by the Genes Unit**

Case 2, the Genes Unit, exemplifies Model B in my typology of research centres. It provides the clearest example of all the cases in this study of how a ‘traditional’ small group of postgraduates and post-docs, working under the leadership of a professor, can retain its internal structure, yet make a significant shift from PBR towards UIBR and some PAR, that is, a shift into what has been termed a second academic transformation, with incorporation of a third mission. The unit also provides a clear example of how a research grouping which seemed very stable and innovative during the first interviews in 2000 could shift to being much more fragile within the short space of five years leading up to the second interviews.

**Emergence of a small new (real) structure: Origin of the Genes Unit**

In some ways, the new (real) Genes Unit, established in the mid-1990s, came into being even more by chance than the new (real) Agriculture Centre described in Case 1 (established at about the same time). This unplanned origin reflects a lack of clear intention at the time on the part of HEIs in South Africa to develop such use-oriented research units and centres for industry. The new Genes Unit emerged at a time when the academic who later became the professor-director of the Unit happened to be visiting South Africa (his country of origin) for personal reasons, which required remaining in the country for well over a year. It was formally located within a faculty of science, but outside of a department. Such a location – effectively floating within a science faculty – meant that there was no clarity on exactly how traditional university research rules and regulations would affect it. It was, therefore, similar to the numerous other small use-oriented research units which were mushrooming across HEIs in South Africa during the 1990s, emerging usually in fortuitous ways.
Its specific establishment arose in the following way. In the 1980s, this professor had completed a BSc abroad, and went on to complete a doctorate by the early 1990s in the exciting and expanding field of genetics, with biomedical research funding. For a few years thereafter, he obtained valuable post-doc (and undergraduate teaching) experience in this research field, including computational analysis at academic research institutes in another country. Importantly, too, from 1994 he gained more applied and commercially oriented research experience while working for two large corporations on work encompassing drug discovery. As the professor put it in the interview in 2000:

[I am part of] a unique breed of people that can understand this data, and those people are people who are both computationally as well as biologically equipped. Through chance, I am one of those people.

But while back in Cape Town in the mid-1990s during what was becoming a lengthy visit for family reasons:

I needed a job. Rather than attempt to become a formal academic as far as teaching was concerned, I decided instead to bring in grant funding from [the country where he had been working overseas], where it is easy to raise funding in this area, and just bring it back. We started with one office and a single donated computer. I brought in industry ties from day one [with links to an international company, related to his previous overseas work]… which was tightly tied to [specifies his subfield of research].

Existing and familiar overseas research networks thus helped in generating some of the financing for equipment and postgraduate student bursaries, as well as funds enabling the professor to obtain the services of a foreign post-doc expert in their specific subfield of analysis, and a European expert computer programmer-cum-technician. This effectively established a use-oriented 'professor-postgraduates-post-doc' grouping around a lab (a room of computers): essentially the same internal structure as Prof. Science's 'traditional' unit (Case 0, but which in contrast undertook only PBR).

In the first interview of 2000, Prof. Genes explained that he had originally sounded out one of the more research-oriented universities with a view to locating there, but 'they laughed at me – they didn't understand what I did'. Fortuitously, a less research-based Western Cape HEI was prepared to accept his developing a research unit in its Faculty of Science. An important factor was that he had already received a Foundation for Research Development (FRD, later NRF) commitment for start-up funding, to cover a part of his own researcher salary. A condition of this funding was that the new lab would include significant numbers of black postgraduates, thereby creating significant postgraduate training in a new subfield of research linked to industry.

Thus, due largely to a series of unplanned events, but complemented by a set of supportive sociological factors in the national (and overseas) context, a high-quality use-oriented research unit 'landed' on the campus of one of the teaching-oriented
Western Cape HEIs in the mid-1990s. The exact structural form it took in relation firstly to the HEI, and secondly to industry, is now described.

The structuring of the Genes Unit within the HEI

The research unit which Prof. Genes constructed was not in any way linked to a specific department, unlike the Agriculture Centre in Case 1 which, from its inception, was loosely linked to an adjoining academic department. Rather, by choice, this professor, officially designated by his HEI as ‘director of unit’, set about building the Genes Unit formally both in the Faculty of Science and in the university as a whole – but in a way which provided considerable freedom to pursue the combination of basic and industry-applied research which he wished to develop. The Unit’s freedom was enhanced by the fact that at this HEI the forms of control over research were still relatively loose, with most systems focused on the undergraduate level:

We have [at name of the HEI] effectively...a liberal arts culture. Undergraduate education is the norm here and if you are in a career track here the emphasis on research is low. The emphasis is high on teaching, and if you graduate a large number of students that is important.

Moreover, this professor had learnt, from post-doc experience at an overseas research centre which was embedded in its university, about some of the advantages of becoming relatively ‘unembedded’. In the interview of 2000 he explained this:

I had some experience with that previously because I worked in [name of genetics centre abroad] as a post-doc, and the innovator in that centre is now quite famous. He also had frustrations. It was one of the top four medical schools in the world. He really knew his stuff but the overheads and problems with dealing with a rapidly moving field within a large institution like [the medical university] were dramatic. To get turn-around on repairs on an essential computer within an hour was simply not heard about, so he made his own network and isolated aspects of [name of the overseas centre] and cut down on overheads.

The Genes Unit was thus constructed from the beginning as follows:

- The Unit director was established in a university-designated post (the HEI agreed to fund part of this, to enhance the institution’s relatively low research and postgraduate profiles).
- Prof. Genes brought in his own researchers, all on contracts (with vetting by the HEI’s selection committee system).
- Funding for the Unit’s separate IT server (allowing greater bandwidth) and all the lab computers (except those used for teaching postgraduates) came from the Unit’s own sources – and these computers were serviced through an off-campus firm.
- The Unit funded its own administrative, financial and technical support staff.42

This set-up clearly gave this professor-director very substantial research autonomy. At the same time, the Genes Unit – though independent from control by any head of department – was nonetheless established with certain forms of accountability to the
Science Faculty and the HEI as a whole. For example, new norms and rules seem to be slowly emerging in relation to use-oriented research structures at our universities; in the case of the Genes Unit, these were embodied in a formal written constitution for the Unit. This included agreements with the HEI with respect to particular elements, outlined more systematically than in most other research groupings:

- a clearly defined mission statement, committing the Genes Unit to: undertaking cutting-edge, quality research in the subfield; increasing national awareness of this subfield, and developing technology relevant to the South African community; and providing national human resource development via education and training in the subfield;
- the establishment of a management board of the Unit, including senior representatives of the HEI, the dean of Science, and one or two other members of faculty, the head or senior representative of the NRF, as well as some further representatives of the national community of this subfield – from industry, other research institutes, etc.;
- the formation of an executive group of the Unit, comprising the professor-director and two others selected from the management board. This executive, together with a senate appointments committee, dealt, inter alia, with all non-academic appointments to the Unit. All academic appointments, including those of contract staff, went through a specially constituted committee and required Faculty of Science approval.

This governance structure for the Genes Unit was the most formal and comprehensive that I encountered among the 11 research groupings I investigated. It was not possible, however, in the time available, for me to investigate in any depth how this structure for Case 2 was working, or whether in reality most of these provisions remained merely ‘rules on paper’, with the Genes Unit carrying on in much the same way as the Science (Virtual) Unit in Case 0 – where Prof. Science ran his lab in a relatively unconstrained way, as long as major university rules were not breached.

But the approach to structure and governance adopted by Case 2 is clearly very important for the future development of South African research groupings – particularly non-departmental, use-oriented groups at our HEIs. Other cases will be examined in relation to such questions of research governance, and the issues arising from these questions will be further developed in Part 3.

Establishing an off-campus commercial company alongside the Genes Unit

The Genes Unit comprised a professor and a few post-docs and research thesis postgraduates, all working in a computer laboratory. This internal organisational structure for research was very much like that of a traditional (virtual) unit – such as in Case 0 – except for the management board system which linked the research grouping to the science faculty (not to a department) and to the senior management of the HEI itself.

A vital difference, however, between Case 2 and Case 0 was the Genes Unit’s external involvement. From the beginning, Prof. Genes pursued commercially oriented
research products *alongside* more traditional international, peer-reviewed journal publications and conference presentations. (Both of these ‘traditional products’ were very substantial, as will be shown.) This gave rise to certain sets of practices and structures, none of which are generally encountered by a grouping doing PBR.

One practice, for example, was that from the outset the HEI obtained 25 per cent of the commercial licence fees accruing to the Genes Unit – initially providing university revenue in the order of R130 000 per year. Moreover, by the time of the interviews in 2000, the Genes Unit’s contribution had become a very important part of the HEI’s total research budget – not unlike the genetic discoveries which had impacted on Stanford University in the 1970s/80s, as described in Chapter 1. This provided the Genes Unit with enhanced status within its HEI, as Prof. Genes made clear: ‘My unit has contributed R10 million [in research income] in the last three years. It has contributed somewhat just less than half of what has come in [with respect to total research income for the HEI].’

An example of an important new structure established here was the company which emerged, linked to this research unit, a year after the Genes Unit’s inception. The professor-director (Prof. Genes) established an off-campus company – in association with a partner – to undertake commercialisation of the technology. By 2000, this company had about eight full-time staff members. Some of the features of the research unit–company relations were the following:

- Prof. Genes’ partner, who had a background in management, marketing and bio-engineering, was heading the commercial company. Prof. Genes also served as a director of the new company, but he viewed his role there primarily as that of research expert – ‘we [in the Genes Unit] are really interested in discovery’ – with others in the company being employed to worry about the commercial side.

- The discovery work undertaken in the Unit was captured by Prof. Genes in this way: ‘Genes found in databases are fragments of fragments, and we bring them together. It’s like walking into a library and finding that all the pages of the books have been torn out and put in a pile. What we’re doing is putting the pages back into the right books.’

- The director viewed the division of labour between Unit and company thus, in the interview of 2000: ‘Fifty per cent of what we do [in the Genes Unit] can be commercialised… The way it happens is we take raw data from the public domain which is in poor shape. We reprocess the whole thing. Then we pass it to our commercialiser [i.e. the company] who then cleans it up, standardises it, productises it, packages it, markets it and distributes it.’ This commercialisation included, for example, a computer software package developed by the Genes Unit, which was marketed internationally by the company from the late 1990s and became a world leader for use in this form of computer-based analysis. The company permitted academics worldwide to use this software for pure research, free of charge, since the company gained from the publicity, and also obtained feedback from academic users about the product’s applicability and about how it might be improved.
• The research appeared to provide extremely valuable products for industry. Prof. Genes stated in 2000: 'Drug-discovery companies can shorten their time of this [type of specific] drug development from ten years to two weeks if they have all of the data. The direct link between the time of development and the time you market is the key. You can reduce those costs dramatically by doing [this type of] research.'

• Around the time of the first phase of interviews in 2000, a consortium of three parties – the Genes Unit, the off-campus company, and an overseas-based international company – came together and were awarded over R4 million as an Innovation Fund Grant by the DST. The off-campus company became the principal manager of the award, from which substantial research money was channelled to the Genes Unit.

• Overall, around the time of the first interviews of 2000, the commercial company’s income from marketisation of the research products paid for most of the administrative and technical personnel needed by the Genes Unit. This income also financed all the (non-student-training) computer hardware and technical servicing, and even funded significant postgraduate student bursaries.

• Much of the company’s computer-based development work was undertaken in an on-campus laboratory adjacent to the Genes Unit’s own computer laboratory, by programmers trained within the Unit.

Given the central role of the commercial company, it can be asked whether the Genes Unit actually needed the HEI: why not leave the university base and merge with the company at its administration office, some kilometres away in the city? Interestingly, it appeared – from comments made by Prof. Genes – that in a number of complex ways the HEI in which the Genes Unit was based did add specific value to its activities. Firstly, the ‘scholarly tent’ of the HEI provided the Genes Unit with academic credibility, despite the fact that it was through its own efforts that the Unit’s academic publication record and attendances at international academic conferences by the director and some of the postgraduates were achieved. Furthermore, the fact of an HEI base added value to the research unit with reference to the commercial world. The professor made the point that peer reviewing of academic publications, with its use of public domain computer databases, ‘helps a lot because it not only publicises what you do but it also gives credibility [with respect to commercialisation of the technology].’

For all the use-oriented research groupings which were interviewed, academic credibility – from a location within an academic milieu, and also from a perceived substantial output of international publications – was of great value outside the walls of an HEI, in relation to clients of various sorts. But it also emerged in the Case 2 interview that, for the Genes Unit, having an HEI base helped in other specific ways. Among these were the provision of good and free office space; extra computers, supplied for postgraduate student training, which were useful for other work; representation by HEI officials to the relevant government department for visas for contracted foreign technical experts and research associates; and, as mentioned by Prof Genes, at this HEI they ‘had access to some excellent students.’
It should nonetheless be mentioned here that almost all directors of research groupings interviewed for the case studies complained about their HEI research administrative services. For the Genes Unit specifically, the slow and cumbersome nature of university administrative and technical services had forced the director to seek outside services through the linked company. Faculty procedures on selection committees were lengthy and caused delays; and it was suggested that sometimes only the upper-level officials of the HEI seemed to appreciate fully the academic work being done by the Genes Unit, and the income which it was producing.

Despite these negative points there were, on balance, a significant number of positive reasons for the Genes Unit to be rooted within the research milieu of an HEI, rather than to move off campus in association with its company. This suggests a number of general points about the complex yet crucial advantages, for use-oriented research groupings, of being based on university campuses. This subject will be further pursued in later chapters.

**Marketisation by the company of the Genes Unit’s UIBR and PAR**

A point to be noted is that at times the Genes Unit was being forced to do routine work rather than discovery work, because of the financial benefits of the former for the research programme. As Prof. Genes said in 2000: ‘You pay your pound of flesh. You have to do things like software development that is not directly associated with discovery. It is [however] a worthwhile investment…’

Nonetheless, from the interview extracts quoted earlier in this case study, it can be inferred that what this professor termed discovery work – ‘[g]enes found in databases are fragments of fragments, and we bring them together [in the computer labs]’ – was, essentially, UIBR rather than just PAR. For, as Prof. Genes commented, the Genes Unit undertook basic discovery-oriented research, even though always with its potential application in mind: ‘we pass it to our commercialiser [the company] who then cleans it up, standardises it, productises it, packages it, markets it and distributes it.’

At another point in the interview in 2000, the issue was clearly elaborated by Prof. Genes:

**Interviewer:** What makes you decide what to follow up…why certain research lines?

**Prof. Genes:** That is very simple. If you are a successful researcher you know what will be an interesting problem. I was trained in marketing which means that my job was to stand on the top of the mast with a pair of binoculars and look over the horizon and expect something to arrive within about two years and go down back to the ship. You predict where the market of the field is going, and you develop understanding in that area so when it arrives you are the expert and therefore you are acting on it.
Interviewer: So it is linked to what would then become marketable?

Prof. Genes: Yes. [Though] I tend to worry about that less and less. There are plenty [of] people [in the company] who are around me to worry about that. I am withdrawing a lot more from commercial projects every day. I am much more interested in discovery. It is much more exciting. We knew that [this genetics subfield] is a big thing. No one else knew that… One of the problems we have in South Africa is that [this subfield] is not understood. There is no pharmaceutical industry to say ‘synthetics are here’. The [subfield]-tech industry concentrates on growing things like yeast fungus. It doesn’t worry about medical-related [subfield]-technology… they don’t think about drug discovery [in 2000, the time of this interview]. Drug discovery essentially with [this subfield] is very amenable to small [technology companies undertaking the work, like the one which he helped set up with a partner].

Perhaps the term ‘use-oriented basic research’ would be a more nuanced and accurate way of describing the discovery work undertaken by the Genes Unit, rather than Stokes’s term ‘use-inspired basic research’. But either way, what seems clear here is that basic research in this subfield, centred on genetic analysis, was firmly established in the Genes Unit. At the same time, the senior researchers in the Unit were looking ‘with a pair of binoculars’ to see what components on the horizon could be commercialised by the company linked to the Genes Unit. The work done by the Unit is thus a very clear example of the second academic transformation, now impacting on genetics in a science faculty of an HEI in the Western Cape in 2000 in the same way as it had done on science engineering at MIT and Stanford in the mid-twentieth century, as described in Chapter 2.

It should also be noted that the Genes Unit had rooted itself in an institution in which undergraduate teaching was historically very pervasive. Nonetheless, during the first interview Prof. Genes made it clear that postgraduates were central to the Genes Unit’s mode of operation: ‘I don’t touch undergraduates.’ The next section examines in more detail how postgraduates were trained within the Genes Unit and were central to its work of discovery within the labs. This highlights a significant feature of the second academic transformation: the importance of postgraduates to the use-oriented research work which the new centres/units are undertaking as part of their ‘third mission’. Later in this case study it will be seen how the serious problems that emerged in the Genes Unit were at least partly caused by trained postgraduates, as well as post-docs and other researchers, moving elsewhere and becoming lost to the research work of the Unit and the commercial work of the company.

Development of postgraduate student training by the Genes Unit

In 2000 it was observed that an important link existed between the Genes Unit and the Faculty of Science in which it was located: staff from the Genes Unit provided
five weeks of teaching as part of the coursework for an honours module for two departments in the faculty, focusing on its research subfield.

On the one hand, as Prof. Genes explained, this coursework contributed to practical postgraduate student experience, and to the building up of student computational expertise: ‘We have trained in total 130 honours students over the last three years… [and] we were able to spend about a million rand [donated by a communications company] on equipment and support for funding in training.’

On the other hand, this training also indirectly provided a valuable recruiting ground for the best postgraduates to assist in the work of the Genes Unit:

We provide quite a stimulating environment for students because they see things happening that are not what they normally expect to see in a [name of science] department.

...[But the Genes Unit gains too] because we steal the odd good student who does their master’s or PhD.49 One of the students is looking for a commercial job in [name of this subfield] in South Africa and is able to do that. He can command a significant salary and then grow the business in any way he chooses. That is probably our first commercial individual… The reason why I have high-quality students is because only people who are attracted to incredibly complex and difficult problems will walk into [name of this Genes Unit] and say, 'I want to talk to you.' We don't do any advertising50...[But] I don't touch undergraduates.

The Genes Unit had also appointed a full-time master's graduate to manage an annual series of national workshops which provided training for groups of researchers from South African and other African countries (sent by drug and pharmaceutical companies, and by medical and other research institutes), to develop expertise in the new subfield. Overseas specialists, together with Prof. Genes, provided the teaching for the workshop's short courses. But it was felt that this could be just a beginning: ‘If you do it properly it should cost just under a million rand a year. We have been doing this on a budget of R50 000.’

Networks with other international training groups, including organisations setting up internet training resources, were also being developed in 2000.

In summary, therefore, the international networks of the Genes Unit, together with the income flowing from its associated commercial company, were able to smooth the process of incorporation of postgraduates, not least in providing bursaries and computer equipment. The HEI and its Faculty of Science were enhanced at the level of postgraduate study: for postgraduate students the work of the Unit provided excellent experience in advanced research, including some of its industrial applications. Yet the emerging framework, as for most of the other use-oriented research cases discussed later in this book, was generally ad hoc: this HEI had no formal system of rules, for example, to obligate or facilitate the Genes Unit in these areas of postgraduate or short-course training.
It must be stressed, too, that the postgraduate training was not simply philanthropic work on the part of the Genes Unit. The master's and doctoral students in the computer labs played a central role – under the supervision of the professor-director and post-docs – in the discovery work which was fed into the commercial company activities. As the next section shows, without good thesis students and good post-docs working in the Genes Unit, all operations could be jeopardised.

Five years later, early 2005: Some problems for the Genes Unit

In the first phase of interviews of 2000, Prof. Genes mentioned that he was negotiating with the HEI for the establishment of the Genes Unit director post as a permanent chair. This would serve to stabilise the Genes Unit at the HEI and, moreover, enable Prof. Genes seriously to consider launching a new coursework master's programme in the subfield within the Faculty of Science. Given the instability and precariousness of some of the 10 use-oriented research groupings which were part of the investigation in 2000, these seemed to be vital steps forward for consolidation. It was not an exaggeration for Prof. Genes to end the interview in 2000 by saying: ‘If I am not anchoring it [via a tenured position as chair in the Genes Unit], it is history.’

Soon after 2000, we heard that the chair for directorship of the Genes Unit had indeed been established, funded by the HEI as part of its commitment to raising the level of research and postgraduate training on a campus where the students were predominantly undergraduates. A few years later, I gathered from one of the campus newsletters that the master's training programme in this new subfield had also been launched. Another campus news bulletin featured a story about the Genes Unit, highlighting its steady progress: one black student had been so captivated by one of her honours modules in the subfield taught by the Genes Unit that she had gone on to the new coursework master's in the field, and later proceeded to enrol in PhD research supervised by the Genes Unit, saying ‘I'd like to go back home [after the PhD] and start a [subfield] company there.’ Other news about the Genes Unit, from similar campus newsletters, informed readers that another student had published two prestigious international journal articles based on the PhD work she had done in the Genes Unit's computer laboratory, and had moreover earned this HEI nearly a quarter of a million rand in royalties through the commercialisation, by the Genes Unit's associated company, of some of her research outputs. And, moreover, not only had both these students been funded by the newly established government national network (GNN) – showing significant national expansion of the subfield radiating out of the Genes Unit – but the commercial company had itself also received well over R5 million in funding from a venture capital funding company, adding to the R5 million it had already received from the Innovation Fund of the NRF.

Yet early in 2005, during the second interview with Prof. Genes (now holder of the chair), I was very surprised to find that, in 2004, serious staffing problems had been encountered by the Unit – which, as noted above, had been loosely located outside of any academic department and even relatively unattached within the HEI as a whole.
It seemed during the period of this second phase of interviews that the Genes Unit’s very existence might become endangered by a substantial exodus of research staff.

A central element in the new dynamic for the Genes Unit around 2004/05 seems to have been linked to the setting up of the above-mentioned GNN. This network, emerging a year or two after 2000, with the Genes Unit playing a leading role in its establishment, was funded at a significant level (10 times more than the Genes Unit budget) by the DST to further the research and training of postgraduates in this new subfield. Importantly, the DST had an eye not primarily on the enhancement of academic scholarship and postgraduate training per se, but on the enormous potential that the IP in this field of research, and its commercialisation, might hold for South African industry and the economy. The basic framework of this government-supported network was the development of a series of university-based nodes – not only the Genes Unit at this HEI, but also similar nodes at two Western Cape universities, as well as nationally at other (especially research-intensive) universities. Moreover, a central node was established as a national coordinating structure, with its own new CEO and staffing. The function of the central node was to coordinate a national master’s programme and allied short-course training in the subfield, to take over the provision of online services in this subfield which had been initiated by the Genes Unit, and generally to coordinate government funding and research development in the subfield. Clearly, this initially set up a situation of some potential overlap and competition with the Genes Unit.

The interview of early 2005 with Prof. Genes revealed that a Genes Unit senior researcher, who had also played an important role in the coursework master’s programme, had relocated in 2004 to a neighbouring university to head up the latter’s newly established research unit, as a node for the development of research and postgraduate training in this new subfield – funded by the GNN. Moreover, at least one PhD student and one post-doc (with valuable overseas research experience in this subfield) had moved across, too. In addition, two other post-docs of the Genes Unit had relocated to research institutes abroad. Worse still for the Genes Unit, during 2004 some of its other researchers and software developers decided to join the staff of the central node of the GNN – in part because of its securely funded government base – as did a few staff members of the associated company of the Genes Unit, who had originally been trained within this Unit.

It is not pertinent here to go into the personal and other dynamics which very often impact on research grouping situations such as the above. But I would suggest that a number of important structural dynamics (prevailing also in most of the nine other use-oriented research groupings of this study) were important here. Among these, firstly, was the shortage of skilled researchers for research units in South Africa – especially in a new area of research such as this genetics subfield. Secondly, most of the researchers realised that they were highly sought after by a range of organisations, nationally and internationally, within this fast-developing and exciting academic subfield. Some saw, too, that there was solid and relatively secure government funding for the central node, compared to more tenuous financial support for
junior researchers and administrators in university-based research units. A third structural factor that influenced the situation was the problems faced in retaining researchers at historically less-developed, mainly undergraduate HEIs – compared to their historically more research-intensive neighbours. In this case not only was there a neighbour that was a better-endowed, research-oriented university with, at that time, one of the largest and fastest-growing university research institutes in the country (with well over 50 people), within which the new node was being located, but its Faculty of Science had much better-developed genetics and computer science undergraduate and honours-level courses across a number of departments. From these departments, this new node might well draw its master’s students and some of its future researchers. Thus the move by some of the post-docs of the Genes Unit to this emerging node at a historically more research-intensive university offered considerable academic opportunities in both research and postgraduate teaching and supervision.54

Early 2007: A third visit to the Genes Unit

At the time of the third interview with Prof. Genes in early 2007 it emerged that, soon after the interview conducted at the beginning of 2005, the company linked to the Genes Unit had been all but wound up – simply remaining as a ‘shell for small-scale consulting work by the former CEO’.55 One factor leading to this had been a clash with the central node of the GNN over IP rights and organisational jurisdictions (Kruss 2008). In addition (Kruss 2008), it seems that entrepreneurial inexperience and market-related problems on the international terrain of firms involved in this field of innovation were other factors, along with internal management problems within the firm itself. An added crucial factor, noted already for the period 2003/04, was the difficulty of finding skilled research personnel and software developers with familiarity in this subfield of research. Financial and other support from some government departments was not as forthcoming as had been expected, further contributing to the problems.

In this situation, the innovative Prof. Genes sought to fall back on the strength of his home university base. This HEI, with its historical underdevelopment under apartheid, highly valued the research niche and research reputation which the Genes Unit had come to hold, and strongly wished to sustain its development. With the support, therefore, of senior officials of the institution and of his own Faculty of Science, he obtained university funding for a few more positions within the Genes Unit, which allowed for the appointment of three senior research project leaders from diverse places abroad. During 2005/06 the number of doctoral and master’s students grew slightly, international publications remained solid, and efforts were made to continue cooperative research projects with some other university laboratories in Europe, the USA and elsewhere. In addition, a short-course provision of modules at master’s and diploma levels in this subfield of genetics was continuing after 2006 – running as a cooperative agreement between a leading overseas university and the research units of Prof. Genes and the neighbouring university.
By early 2007, therefore, the Genes Unit had all but lost its links with the commercial company, and was seeking to consolidate itself, at its core, as a mainly UIBR unit, hopefully linked over the next few years with a range of clients. Building up its own internal academic enterprise of quality research and postgraduate thesis work, as well as enhancing links with similar international research units in this expanding genetics subfield, was essential for this to succeed. Perhaps most crucial of all was the ability to attract high-quality senior researchers into the Genes Unit. Yet one wondered, in 2007, what lay ahead for the Genes Unit, since it was without any base in an academic department, and was not located in one of the elite universities of South Africa. The question of its future was posed even more sharply at the end of the third interview, when Prof. Genes mentioned that he intended to go on sabbatical for a full year in the USA later that year.

**Concluding summary**

Case 2, the Genes Unit, shows clearly how an internal organisational structure the same as that of the small, PBR, ‘traditional’ virtual unit analysed as Case 0 could be utilised for UIBR and PAR, linked to a commercial company and its clients. Prof. Genes constructed a new real unit, the Genes Unit, with a similar internal structure, though located not in a department but in a faculty of science, under a board of governors, and with a formal constitution drawn up for the Unit and its activities. There were, however, other significant differences between Case 0 and Case 2.

Alongside the Genes Unit, a colleague of Prof. Genes had formed a company to market the Genes Unit’s research products, which were derived primarily from its UIBR within this new subfield. Most importantly, revenue from the company not only provided the university with significant research-derived income, but also enabled the Genes Unit to fund much of its administrative, computational and research assistant salary costs, and even some postgraduate bursaries. Thus, as is characteristic of the second academic transformation, there emerged new features of a symbiosis between university research and industry development. Interestingly, too, although the Genes Unit – largely for unplanned reasons – had been established at an HEI historically focused on undergraduate training, the niche established by Prof. Genes included significant postgraduate training. Moreover, unlike traditional Prof. Science within his academic department of a faculty of science, Prof. Genes was not involved in departmental or university administrative and committee work.

Despite my finding in 2000 that a fairly solid and innovative research unit–commercial company relationship had been established, I discovered during the second phase of interviews, and even more strongly at the time of the third phase, that significant challenges had emerged. A series of factors were creating problems for the commercialisation of the outputs from the Genes Unit’s UIBR work. These included: IP and other tensions between the central GNN node and the Genes Unit; issues arising from the establishment of a similar research node at a neighbouring more research-intensive university (as part of the GNN scheme), which resulted in some post-docs and PhD students from the Genes Unit relocating there; and
problems related to two other post-docs leaving for research opportunities at academic institutions abroad. Not least, without substantial additional government funding, the commercial company ran into financial problems in the rough world of international business competition in this new genetics-based subfield of industrial innovation, resulting in its virtual closure by 2007 (see Kruss 2008).

This case thus clearly illustrates that building viable U–I linkages was not as easy as it had seemed to be during the first phase of interviews in 2000. By 2007, Prof. Genes was seeking to reconsolidate his Unit, with significant support from the senior and faculty-based leadership of the HEI, through the overseas recruitment of three senior post-doc researchers. In addition, he was aiming to expand the numbers of master’s and PhD students, who would be able to play a significant role in the daily research activities of the Genes Unit. The long-term vision seemed to be to create three or four research teams led by such seniors, all directed by Prof. Genes – not unlike the internal structure of the Agriculture Centre (Case 1) in 2000, outside of but linked to an academic department. Only the future will tell if such a mission bears fruit at this HEI, which exists in competition with its more research-intensive university neighbours.

Case 3: Model C, use-oriented research, exemplified by the Space Lab

Case 3, a new (virtual) centre that exemplifies Model C in my typology, was based in the engineering faculty of one of the research-intensive universities of the Western Cape.56

The ‘network of professors’ involved in this lab work is categorised here as a ‘centre’ because within their Space Lab in the Department of Engineering,57 each professor had a group of postgraduates in their research team – like the senior researchers and their respective subgroups in the Agriculture Centre (Case 2). It is classified as ‘virtual’ because, unlike the Agriculture Centre, this loose cluster or network of departmental professors was not formally recognised as a research centre or unit by either the university or the professors themselves. And, most importantly in terms of activity, it functioned loosely as a network of professors rather than as a hierarchy with a director leading subgroups of senior researchers, as exemplified by Case 1 in 2000.

The 1990s: Nearly 10 years of struggle to build and launch a microsatellite

South Africa’s first space microsatellite was launched by the university engineering research grouping called here the Space Lab in 1999, by arrangement with the National Aeronautics and Space Administration (NASA) of the USA, which allowed the small satellite to piggyback on the NASA satellite launched that day. For the South African researchers, an important environmental research purpose of the project was to take high-resolution photographs of the country’s vegetation. Of note is that by 1999, in the Space Lab that had been developed as the base for this research within the engineering department, about 25 staff years and 150 master’s
and doctoral student years had gone into the project, the total estimated cost of which was just over R10 million.58

A few academic staff and postgraduates of the Space Lab travelled to the USA to assist with the NASA launch, while a large group of academics, postgraduates and others watched on a large TV screen in the auditorium of this engineering department – and raised an enormous cheer when the satellite took off.59

This might have been seen as the culmination of the Space Lab’s achievements over the years. But their work continued to develop and expand. By the time of the second phase of interviews in early 2005, a commercial satellite company was flourishing in the science park near the university. In the Space Lab, too, use-oriented research in satellite systems seemed to be flourishing in 2005, as did research in aeronautical systems and biomedical systems (especially medical sensors and cameras) linked to the satellite research and its associated commercial company.60 And in early 2007, I found the Space Lab (now undertaking a broader range of research) to be well established, with some new developments linked to a proposal to the NRF for a CoE associated with this research.

Origin of the satellite research project in the early 1990s

The story of the Space Lab begins around 1991, just at a time when the apartheid government was closing down its military satellite programme, with no clear inclination of support for any new, peaceful satellite initiatives.61 Nonetheless, a core group of academic colleagues within the engineering department at the university initiated a novel and, for the period up to 1999, non-commercial research project. Its central aim was to launch what would perhaps be the most complex international ‘student-designed’ satellite, developed in an expanded master’s/doctoral thesis-based programme based in the Space Lab.

There had been a history to the university’s research in this space engineering subfield: in the three decades since the Russian launch of the first satellite Sputnik, in 1957, the Faculty of Engineering had developed interest and expertise in satellite technology and communications engineering, via links with NASA scientists.62 But the 1991 initiative was on a new and more ambitious scale. As the core group of professors centrally involved were to note (in an article collectively authored by them) soon after the satellite launch of 1999, ‘to date [1991–99] there is still no government funding specifically available for space projects.’ Yet with moral support from their faculty dean, and with an industry advisory board set up to channel funds, they began a project about which they wrote, in the same article, that ‘possibly the most remarkable thing about [name of Space project] is that it was completed and launched.’ They explained further:

The project leaders [these engineering academics] started with no money, students, nor space track record. However, they had a wide circle of friends in the Amateur Radio community and the electronics industry who helped
find support and could often arrange free access to test facilities. Over fifteen company and private donations were ultimately found for [name of Space project]. Research grants from South Africa’s Foundation for Research and Development to support [name of their larger Engineering Systems group] supported some graduate student projects which formed part of [the Space project]. The government’s THRIP programme also provided matching funds for some industry donation. The donations first had to be found by the project leaders, who probably spent as much time managing funding and promotion as in technical leadership. [Name of Space project] was thus funded, built and tested by a network of friends throughout the South African electronics industry. Total funding into the university amounted to about US$2 million [around R10 million at the time], of which half was used for student support, with the rest being spent on engineering materials and processing.

Solving problems of funding and of large-project management

A major feature of many of the 10 use-oriented research groupings investigated in this study was that the academics involved underestimated problems of funding and management once they attempted to go beyond the scale of a small research unit into larger projects undertaken by both ‘real’ and ‘virtual’ research centres. The quotation immediately above suggests how this took time away from normal research and teaching work. This was well expressed in an interview in 2000 with one of the Space Lab professors, who noted how funders of research in South Africa (the NRF and others) do not usually provide funds for such vital research project administration and management:

I think for at least the period 1993–1997 most of my research time and all of the time I would have had available for [engineering] consultation went into managing the [Space Lab] programme. My role was more in terms of the financial and contractual management side of the programme…On average there were about twenty-five students working on the programme and four or five technical people, and about four or so electronic systems lab engineers…I had to handle not only THRIP but twenty-one other sponsors…Obviously one realises that you have to put in a lot of work before you get money. It means it is far, far more than a professor can handle apart from [the work of] his academic year…The NRF will never give money to fund the hours and hours of management that goes along with this. They are more than happy to pay for technical work but they didn’t realise managing a project like ours – which spent a couple of millions per year – takes a lot of management effort, and who pays for that?…

The professor then mentioned that they had utilised a few of their own engineering departmental administrators, but had subsequently hired a dedicated consultant to help, particularly with financial management: 'Initially we contracted him for half of
his time but now with all the initiatives we are taking to start the next satellite work [see below for what will be termed Satellite phase 2], he is full-time.

The microsatellite project thus provides a clear indication (further explored in Part 3) of an essential problem of such larger centre-type groupings: a serious underestimation, by themselves and their universities, and especially by their funders, of the financial and management skills and costs (overheads, person-time) involved in more substantial use-oriented research. During the 1990s phase of the satellite project, the leading academics and their engineering department in many ways absorbed the real costs themselves.

**Why build a satellite?**

Why build a satellite? This is an important question to ask. It must be posed, since a number of obvious reasons are provided in the satellite project documentation at the time of the launch (1999), as well as during the first phase of interviews in 2000. These reasons encompass the priority goal – of postgraduate engineering training – as well as the secondary goals or gains in terms of the growth of high school, satellite-linked science projects, the symbolic value for the university and country, and the training of black telecommunications engineers at the nearby satellite station.

All these reasons are important, and they are discussed in the next section. However, with the benefit of hindsight, after the third set of interviews of early 2007 when the commercial second phase of development of satellites (i.e. Satellite phase 2) had already become a reality, it seemed to me necessary to interrogate these obvious reasons more closely. Issues of the closing off of military satellite technology possibilities around 1990 in South Africa, and the parallel new possibilities of commercial industrial opportunities emerging in the 1990s towards the end of the Satellite phase 163 cannot be ignored as reasons for building a satellite at the university. I thus argue that the role of use-oriented satellite research for long-term commercial industrial development was important in shaping the satellite project, even from its inception around 1991, though this was not obvious in documentation and the first set of interviews in 2000. In other words, I suggest that this Space Lab research work in the 1990s was itself a response to the perception among the researchers that commercial opportunities were opening up for stronger U–I linkages associated with the triple helix and third mission of the second academic transformation. But the discussion here will focus first on the self-expressed reasons of the participants in the research.

**Providing for postgraduate training incorporating ‘multi-skills’**

During the first phase of development of the satellite up to its launch in 1999, a vital aim of the research project for the professors in the Space Lab was the training of postgraduates via master’s and doctoral research thesis work within their lab. Therefore, postgraduate training within the department became core work for this department-based (virtual) centre (a cluster or network of professors) from the
beginning – in contrast, therefore, to the work of the Agriculture Centre (Case 1) and the Genes Unit (Case 2), which were both located outside academic departments in 2000.

Up to the time of the satellite launch in 1999, nearly 100 students had become involved in the satellite programme, with over 40 master's and four doctoral degrees earned. The teaching philosophy of the four to six tenured engineering academics involved at various points during the 1990s aimed explicitly at providing interdisciplinary research work for postgraduates, in diverse fields of engineering as well as in broader scientific fields such as applied mathematics and computer science. In addition, the students gained practical training in management and personal skills in parallel to their academic work. And although the satellite project was formally located in the Space Lab of the broader ‘engineering systems’ group of the department, a few academics from related engineering and other science-based departments became involved in some components of the research and supervision. Thus, the satellite project had trans-departmental components, though not nearly as strongly as the Agriculture Centre did at the time of the first interviews.

One of the professors pointed out in his interview in 2000 that industry saw the value of this type of training for postgraduate students: ‘We are developing manpower [sic] in a different way, by giving them a challenging project.’ He felt that most students who had been on the project had thereafter quickly found jobs within South African industry, with some also forming their own small consulting companies. The professor added: ‘In the medical profession, a doctor wouldn't be allowed to practise if he was taught by another medical professor who never did an operation. The same applies with engineering. Lecturers have to have a certain amount of continual exposure in projects, like this one.’

An interview in 2000 with a postgraduate student who had been involved for some years in the satellite project, and who had just graduated with a master's degree in engineering, provided important insights into the student experiences:

Master's graduate: When I came here in 1996 I was a postgraduate [master's by thesis] student. I was still that in 1997. In 1998 I was appointed as a lab design engineer. At that time my role in the satellite [project] had become quite extensive... at the end of the year I realised I wasn't going to be able to finish my thesis so I asked for another year. At the end of each year I asked for another year. Eventually it took four years, which was too long... [but,] yes, I gained enormous experience. Eventually I also did my thesis on the work that I did on [name of Space project]... Since then I have been appointed as a junior lecturer at the university... [and] I'm involved with the upgrading of the satellite. The software is changed. We continually find things we want to change. We modify and test...

Interviewer: I heard you were one of the people who went over to America with the satellite, to look after it on its journey, and then you were part of the team for the launch with NASA?
Masters graduate: ...It was a once-in-a-lifetime opportunity you get. It was the first South African satellite. Just from that point of view, it is something you can’t really describe. What was nice about it was seeing how things are done on that side. You don’t get down to a very technical level but at least you get an overview of the high-tech space world in America. That was also very inspiring to see. It opened up my thinking in the direction of going over for a few years to work in America. I am still considering that quite seriously. If things don’t happen here, I will go to America.

[and towards the end of the interview:]

...one of the main reasons why this project succeeded was because there were a group of people who were prepared to work with very little pay. Money wasn’t an issue. They were doing technical work which was enjoyable. They worked weekends and late nights.

Certainly, the estimated 150 person-years of master’s and doctoral student time, at very low labour cost, was an essential component in making this research enterprise feasible. At the same time, it appears that the Space Lab probably succeeded – more than any of the other research groupings investigated – in one of its central aims: to link use-oriented research by academics with high-quality training of master’s and doctoral students in multiple academic skills, as well as in additional project management and personal skills.66

Educational outreach for school science

Although education outreach for school science was not regarded as nearly as important an aim as the master’s and doctoral training, it was reported in the interviews of 2000 that there had nevertheless been a secondary spin-off from this satellite project, involving the enhancement of science project work among schoolchildren. This was organised through the ‘Space school science’67 project, funded from 1997 by a South African company, and came to involve over 40 000 schoolchildren at the time of the satellite launch.68 Historically disadvantaged schools were often included, with the project providing instructional workshops for science teachers on the use by learners of specially packaged electronic kits, to harness interest in the sciences – using the satellite project as an underlying theme. When the satellite was finally launched, some schools and colleges became involved in their own space science sub-projects associated with the orbiting satellite (for example, monitoring radiation damage). Linked to all this was an explicit aim on the part of this faculty of engineering of increasing support for engineering studies among schoolchildren. As one of the Space professors said in an interview in 2000:

Unfortunately, a lot of them [schoolchildren] go for accounting at school level because it is attractive and the salaries are attractive, but before you count the money you have to make it. How do you make it? You make it by productivity and [through] producing [services] or technical services where no one else has the skills. Once you lose that you will become a net
buyer in the country...If you don't excite [the schoolchildren] they won't go [into engineering]. In the end you will buy computers and networks and know-how from overseas. That is a problem in Africa.

Two of the use-oriented university research groupings described in these case studies (Case 3 here, and Case 5 described later) allowed some of their social responsiveness activities to become significant – to the extent that at least one research-intensive university viewed this outreach towards civil society as ‘impeding’ more ‘serious’ academic research outputs (such as peer-reviewed publications), as will be seen in relation to Case 5. Yet, as noted in the discussion of the ‘fourth helix’ in Chapter 3, in a poverty-stricken society such as South Africa de facto demands made by external communities on university academics for socially responsive, third mission activities can be very strong. Moreover, if such work is carefully selected, there can also be positive feedback effects into university teaching and research.

This satellite research group allowed room for an innovative outreach activity through its schools project, while at the same time retaining research and postgraduate training as its main foci. Admittedly, the Space school science project activities were relatively minor in comparison with the overall Space research work, including the later commercialisation activities. At the same time, the outreach into schools seems also to have attained some of the feedback goals. As one of the Space professors said in early 2005: 'Many of them [the newly enrolling students], when they come here into the engineering faculty and fill out their survey form on the first day, say they have had [name of Space school science project] exposure.'

Symbolic value for the university and the country

A subsidiary aim, which should not be underestimated, was mentioned by one Space Lab professor during his interview in 2000. During the post-1994 period of emergence of a new ANC government, this university, including the engineering research laboratory, was concerned about future changes. The professor felt that one group had withdrawn support, it seemed, ‘just because you are an [apartheid-linked] university’, yet ‘we just carried on and made new contacts’. In particular, he expressed a belief in the value of their scientific excellence, linked to the satellite as a symbol of engineering at this university and its association with development for South Africa in general:

...[with the application of high-level research] top class, the front line, it is obvious if you do something challenging it will help you [the university and the country] to stay up there. People support that. The new government supports that strongly...In South Africa nowadays there are so many important things to do and so few people. As long as you try and do something that is to the benefit [of society] and make sure you let people know, and it is in line with what the country wants and there is development, you will get support, not only moral support but also financial support which is the bottom line if you want to run a lab.
There is no doubt that the dramatic launch of the satellite in 1999 created symbolic value for science activity based at this university, and also for the country as a whole, especially in relation to the high-profile 'space exploration' associated with NASA and the USA. This underscores the role of basic science as image-builder, alongside its function as the foundation for more use-oriented UIBR and PAR.

Extension into training of black professionals in telecommunications

Another spin-off from the Satellite phase 1 should be noted as part of the complex set of achievements of this research grouping during the 1990s. In 1998, there was a chance meeting between a senior government official of the Department of Communications and a professor of the Space Lab. This led to the latter offering to train, annually, groups of black BSc graduates, mainly from historically black universities, who were employed in this government department. A bridging postgraduate diploma (PD) in satellite-linked engineering was developed by this faculty of engineering, leading to a master's in engineering science. For some portions of each month, students were accommodated at the relatively nearby satellite tracking station, where training and lectures took place, but they also spent some periods in the Space Lab itself. As one professor put it in his interview of 2000:

If you run this [PD and master's] programme for five or ten years it will make a huge difference to skilled manpower [sic] in this high-tech field, which will make the workforce more [racially] representative and therefore the Department [of Communications] is prepared to put in money...We used the basis, the way of working established on [name of Space project], to serve a new need.

A second professor added in his interview about this programme: 'Although we use satellite communication as a “horse ride”, they can go into computer software [afterwards, if they wish]. They get their master’s in Engineering Science [which is broadly applicable in a range of industries].'

During the follow-up interviews in early 2005, I found that this PD training programme in engineering was being phased out, because the new four-year undergraduate programme in all engineering departments was beginning to enrol a wider range of black students than in the 1990s. It was argued that the need for a bridging PD in engineering was thus not as necessary, since black engineers were being trained via the normal and more effective four-year route, with a few then going on to a master's degree. Nonetheless, it seemed that the satellite-linked PD had been a catalyst for the reorientation towards a broader student race and gender profile in engineering.

The role of UIBR and PAR during the 1990s: The Satellite phase 1 of the Space Lab project

It is important to consider the role of UIBR and PAR during the 1990s phase of the Space Lab project – the building of the satellite. Admittedly, interviews with two of
the Space Lab professors in 2000, as well as the project documentation for Satellite phase 1, seemed to stress the training of postgraduate students rather than the needs of industry. Nonetheless, it is my hypothesis that, prior to the satellite launch of 1999, UIBR and PAR, linked to ideas and hopes of eventual significant commercial industrial opportunities, were significant, even during this early 1990s phase, alongside the expressed goal of training postgraduates.

With respect to UIBR, I argued in Chapter 2 (especially with respect to MIT and Stanford) that American military applications were often closely linked to science–engineering research at universities in the USA – especially because, for the military of that country, UIBR at leading research universities was often viewed as even more valuable than PAR (because the American military often undertook PAR in-house or through industry). With respect to the university involved in the Space Lab, it has already been noted that its Faculty of Engineering had developed expertise after the 1957 Russian Sputnik in engineering science subfields of space science. Moreover, both the interviews and the documentation of 2000 confirmed that links with NASA scientists in the USA had been well developed by engineering professors at this university during the period from the 1960s to the 1980s. The Space Lab professors who led the satellite project in the early 1990s were conscious that military use of this technology was being phased out at that time, and that the priorities of any emerging new government after the 1994 elections would be to reinforce the phasing out of military priorities. They turned their focus towards possible future commercial industrial priorities of companies in South Africa (and internationally) in the area of satellites, and also to allied technologies that might prove to be routes to acquiring future funding, as can be seen in this quotation from the 2000 interview with one of the Space Lab professors:

The point is that [name of Space project] was the flagship project of the [name of ‘engineering systems’ group]. What we are doing is developing complex electronic systems and the industry knows that satellite engineering will be a limited effort in the country, important as I said, but limited…With the focus on electronic systems development, it means that even though they [postgraduates in the laboratory] may have worked on the satellite project they will have techniques and capabilities which will be applied in any electronic systems…

There is also some evidence pointing to an awareness among those involved in the satellite project of the significant potential for general applications of microsatellite technology, showing that the research had been use-oriented from the outset. This was elaborated on by one Space Lab professor in his second interview in early 2005. He had been located in South African industry in the late 1980s following the completion of his engineering PhD abroad and had tried to persuade industrialists to develop microsatellite technology expertise, before deciding that it could be done better, at least initially, from within a university laboratory:

It was ’92, I was still in industry…this small satellite idea – I tried to run it from a technopark where I was in industry; I tried to convince people in
industry to build one, because it was supporting another big project, the GreenSat satellite, which was funded by the government, but it was never completed…There's this big [GreenSat] project which took many, many millions of rands, but it's not useful for training the future generation of aerospace engineering – it's too big and it's too important; to do it right, you'll only use professional people [not postgraduates] to work on it. The proposal that I made was that industry should fund a small one – a microsatellite development and thereby lock in the training work done by universities with the needs of industry. I tried that; I couldn't get much support from industry alone, so at that point [names of the five other engineering academics involved] – they were all at university, and I actually decided to come to university to do it from the base of the university – how to get industry drawn in and all the other sources of funding that the university has access to, like THRIP funding, and NRF funding. And that was actually a stronger position, to try and do it from university than from a particular industry. But once the university decided they want to do it and they could convince industry that irrespective of whether we actually build a satellite or not, the kind of skills that we develop – computers, control, electronics, light structures – those are all useful skills [for industry], but we would build it around a flagship project – it was easier to do it from the university, because it was sort of part of our mission to develop human resources to do research…and you had to have the right mix of people who would do it as a team [of academics]…

This quotation supports the hypothesis that the industrialists and academics were all aware that, if the project succeeded, it might have important future commercial–industrial possibilities. Industry had begun supporting government in the development of a larger satellite (GreenSat) in the early 1990s, where training of students was not an aim. But, once the microsatellite project got under way at this university, research linked to industrial application was soon dovetailed with the training of students. So, from the project's inception, UIBR and PAR, allied with longer-term commercial–industrial needs, was driving Satellite phase 1 of the project. Alongside this, the other reasons given above were also important to the whole enterprise – but were not independent of the push for UIBR and PAR and their potential for industrial innovation.

The professors in the Space Lab had thus constructed forms of UIBR and PAR from a laboratory base within one academic department. The department, and the academic network or team constructed in this way, provided a crucial foundation for cohesion and stability, enabling the Satellite phase 2 with its direct links to industry to take off.

**Satellite phase 2 after 2000: Expanding the commercial–industrial applications**

From the second set of interviews of early 2005, it seemed to me that these use-oriented professors of the Space Lab had succeeded in achieving the goal of UIBR
and PAR, with numerous commercial possibilities, arising during what became known as the ‘phase 2’ period after the microsatellite launch of 1999.

An important factor for this success in the years after 2000 was that basing the early pre-commercial developments in a university laboratory during the Satellite phase 1 made available a massive amount of cheap postgraduate labour in science–engineering research for the satellite’s construction and testing during the 1990s. Another vital factor – more than for any of the other research groupings investigated in this study – was the right mix of people. For, as will be seen with respect to the other case studies, the glue holding together the senior members of a research group as a functioning entity needed to hold fast. The group of four to six academics linked to the Space Lab not only shared many attributes (white males, same language, similar engineering backgrounds, similar aspirations in teaching/research/industry applications, and so on), but some of them had actually been academic mentors of the doctoral theses of others in the group, while the latter were students at this university.

It should be noted, too, that during the time of the 2005 interviews, the commercial–industrial developments of the Satellite phase 2 were significantly greater than had seemed possible when the first interviews took place in 2000, although a few of these developments were already emerging in 2000, as mentioned at the tail end of an interview with one of the professors at that time. He explained how, after the 1999 launch:

...we started getting more and more requests from overseas research units and universities, and even commercial companies who wanted to buy some sub-systems, which we have now in space proven on [name of Space project]. Obviously that is not the work of a university laboratory. You can’t ask the students to do that, it’s not their job. Academics shouldn’t spend too much time on that because they have other things to do. We created this company called [name of Space company, in 1999]. It is not only space systems but it also connects into information systems. We have full-time engineers who have nothing to do with the university and we have clients and contracts. We have to deliver a complete satellite to the one client [from overseas]. We have to develop it with the engineers [from overseas]. The engineers come here and sit in a separate room, not the lab. We rent space at the Faculty [of Engineering]. We developed a new satellite for them and the engineers go to their own country and are able to do more of the same. We have developed sub-systems for a satellite that is going to be launched by Australia two years from now. It is really commercial business flying out of the research effort. The university owns 26 per cent of this company and the academics and some of our key staff who have been working on the [name of Space project] programme own the rest. We give our expertise and some guidance there but it is run by a company. It is company employment. The purpose of the company is not really to do too much research because it is expensive and it [research] is a long-term thing. The company does send a good percentage of its profit back to the
university to do research here. That is another source of income to the research lab.

By 2005, this second phase had become more consolidated.\(^6\) The company was physically well established in the nearby science park, incorporated within a wholly university-owned company – reflecting the rise of U–I linkages in the Western Cape during the previous decade, an indicator of the spreading of a second academic transformation at this university.\(^7\)

The Space company had a board of directors (over half of whom were professors who had been involved during the Satellite phase 1, but important new industrialists and financiers had been brought in too), and there was also a management team (again including some professors and ex-students of the Space Lab project). On looking at the ‘products’ and ‘services’ information section of the Space company website,\(^7\) one could see that complete microsatellite development and its marketing were important, but a range of other allied products were also advertised, including satellite cameras, magnetometers, VHF/UHF communications systems, and professional training courses in satellite development. There had thus been an industrial diversification beyond the construction of microsatellites.

In 2005, one of the Space Lab professors explained that their university research and the allied company still focused on the special expertise developed during Satellite phase 1 – earth observation satellites with cameras – rather than on the area of satellite communication (TV, telecoms, etc.), which was another big area of international R&D. Their industrial products were based on a wide range of research done in the Space Lab. Furthermore, by 2005 a Space Lab subgroup doing research on aeronautical systems (focusing on automatic-remote flight control of aircraft) had become more important than the satellite systems subgroup, which was nonetheless still thriving. The professor informed me that the Space company currently had a staff of about 50 people, including management and administration. He estimated that about 35 were engineers-scientists, with over half of them being ex-postgraduates of the university. Other master’s graduates from the lab had set up engineering businesses, which were being contracted by the Space company for specific technical and manufacturing services.

In this interview with the Space Lab professor, very interesting insights emerged with respect to the internal dynamics of the research grouping over the period 2000–05. The core group of professors who had initiated the satellite project spanned a range of academic-cum-industrial positions by 2005:

- one had become a dean of engineering, devoting only about 5 per cent of his time to research consultancy with the Space company;
- a senior professor had retired early from academia to become a full-time engineering member of the Space company management team;
- another professor was spending 80 per cent of his work time as a business manager in the Space company, and only 20 per cent of his time in the engineering department as associate professor;
• another professor was working 60 per cent as technical manager in the Space company, and 40 per cent in the department as a professor.

However, the research grouping had not become unstable or fragile due to this core exodus (unlike Cases 1 and 2 above, and some of the other groupings to be discussed in the next chapter). An important reason, as already suggested, was probably the fact that the Space Lab itself, with its network of professors, had a base in an academic department. For example, in 2005:

• two of the original six were working nearly 100 per cent in the engineering department and were leading research projects within the now enlarged Space Lab;
• a new senior lecturer, who had gone to MIT to do a PhD in aeronautics after completing his master’s in the Space Lab, was back in the department and leading one of the Space Lab research projects;
• a few other academics in the engineering department were now also involved in the Space Lab, including some of the departmental junior lecturers who had earlier obtained master’s degrees via the satellite project.

Very importantly, therefore, with respect to this structure of a ‘network of professors’, although some senior academics had left the research grouping, others – via the departmental structure of tenured academic staff – could come into the Space Lab and fill the gaps. The functionality of being based within one department was also apparent in relation to the laboratory development of the next generation of researchers. I asked the professor: ‘Have you got new master’s and PhD students [in the Space Lab]?,’ to which part of the reply was: ‘The lab is full and it can accommodate thirty to thirty-five students at any time…we are at the point of concluding new theses projects…for a new-generation South African satellite.’

In conclusion, therefore, by early 2005 the UIBR and PAR of Satellite phase 1 appeared to have given birth to a vibrant and innovative phase 2, which included a commercial–industrial company. This engineering lab was also being provided with a stream of new senior researchers – some even at associate professor level – through the departmental structures; in addition, the lab was also continually training new researchers through postgraduate thesis work. It seemed that all this was due to ‘home-grown’ factors within this Western Cape university and the department itself. But, as suggested in the Introduction to Part 1, there was one more big development with respect to this case, which emerged during the early 2005 interview.

The idea of a wall between academic lab and industrial company: Unexpected influences of MIT–Stanford

As has been observed, the internal structure of the Space Lab research grouping was essentially that of a virtual centre, comprising a cluster or network of four to six professors, all based within an academic department. Two additional elements relating to what might be called the ‘Space (Virtual) Centre’, not apparent when the first interviews were undertaken in 2000, will now be explored in relation to
comments made during the interview with one of the Space professors in early 2005. These are:
• the significant strength of the sociological ‘glue’ which held this particular grouping of professors in this (virtual) centre together;
• the unexpected influence of MIT–Stanford on this Western Cape laboratory, particularly with respect to its internal structure and the mode in which it linked to the company in the science park.

To begin, it is useful to recall how Frederick Terman, as head of electrical engineering at Stanford University, sought to build links with physicists and other scientists (for example in the Microwave Lab) (see Chapter 2). In this way, he aimed to ensure a strong academic research foundation for all their engineering work, linked to the emerging electronic industry in the California region. The Stanford Department of Electrical Engineering provided a framework for Terman to build up a number of core research groups, with which Silicon Valley and other industries became associated.

In certain ways, the Space Lab emerged as a similar core structure within which the microsatellite was developed during the 1990s, and with which the Space company in the nearby science park became linked after 1999. Some of the glue of this structure comprised, as noted, a team of four to six electrical engineering tenured academics within a department – all with close personal and historical ties to that department, and to one another. I stumbled on the extent of these ties by chance in the follow-up interview with one professor in early 2005.

At the beginning of my interview with him, he had described clearly how the six academics formed the basis of the satellite project. Further into this interview, as described in the Introduction to Part 1, the discussion stumbled upon another crucial aspect of this history: the fact that in the 1980s, Q and R had done their PhDs in engineering at Stanford (Terman’s department) while, way back in the late 1960s, their senior professor and department head, S, had done a master’s in a satellite-related field at MIT. Prof. Q explained that they explicitly took the model of Stanford with respect to university–industry linkages, and constructed a similar mode of research here in their own engineering department in the Western Cape.72

Interviewer: ...I've talked about a concept called ‘fundamental-applied’ Well, that's what you're doing. You're doing fundamental, but you're thinking of its application?

Prof. Q: Sure, ja. And we [academics] do a bit of consultation to know what's going on. But we know our roles...Prof. U was at Surrey [University] Satellite Technology. He's got the UK model in his mind...Just on the same campus, a few hundred metres away they have a company called Surrey Satellite Technologies Limited, a private company. And again, they are careful in distinguishing between the two roles.

As I have said, we couldn't start that way. We had to do it in one lab with students, getting the industry to support us. But once we had one demonstration working, the [name of Space project], and we could generate
enough [output], then we could split it. So it’s difficult to start totally separate; that’s the difficulty I had in the beginning, in the ’90s, in convincing industry to do its thing separately at the university – it wasn’t so easy. We had to start the thing within the university, with a big picture in mind, and run it that way; demonstrate success, and then it was possible to split them.

Interviewer: So, when you started the thing in the early ’90s, you already had a vision of this?

Prof. Q: Ja.

Interviewer: Really! And some of that vision was about seeing how Stanford had managed it?

Prof. Q: Ja, ja. But you first had to prove that…You have to prove yourself as a group at university first; you know, demonstrate that you can actually put out something and make it work before you are given the opportunity to commercialise.

Some thoughts after the 2005 interview with Prof. Q

The conversation with Prof. Q in 2005 provided some crucial insights into factors which appear to enhance rather than impede UIBR and, in this case, interlinked PAR within a university.73 In summary, it seems that the key factors are the following:

• There needs to be a ‘protective shell’ to contain, nurture and help shape the growth of a research grouping. A department structure is not the only such shell (see Part 3 for further discussion). But if structures like (what I have termed) stand-alone ‘real centres’ are underdeveloped or poorly understood or underfunded, traditional departments do provide a framework for a ‘virtual’ centre or network of professors as in the Space Lab – into which new senior academics can enter when experienced researchers leave. Moreover, departments are places where new junior researchers can be trained up through postgraduate work within research teams. And when there are close historical, social and cultural ties to bind the layer of senior professor-researchers together, that is even more valuable.

• For UIBR and interlinked PAR to work and flourish at a university, we need to take seriously some of the lessons learnt over decades in places such as MIT and Stanford, whose research groups and centres have a long history of involvement in the second academic transformation. One of these lessons seems to be that there is a need to prevent role drift (a valuable term used by Professor Q). By linking up their research with industry (or with other civil society organisations – see Part 3), professors at universities can easily drift into mostly PAR, and even into commercial consultancy work of a purely routine nature, without any ‘new knowledge’ components (a trend that will be evident in Case 5, discussed in the next chapter). Because of their lucrative nature, such consultancies can easily develop and expand within research-intensive universities, preventing them from fulfilling perhaps their most valuable societal role, that of providing UIBR at the highest level – incorporating the best of basic research and scholarship within the
use-oriented activities of their labs or groups. As Prof. Q suggested, to prevent such role drift, it seems that a structural separation is vital – not only in terms of actual location (science park versus departmental lab), but also in terms of what the researchers do and do not do within the university lab. This role separation between university academics with their research groupings, and the outside society, is explored further in Part 3 with reference to a range of case studies.

At the end of my 2005 interview with Professor Q, I was left pondering whether this Space Lab as (virtual) centre might also die, like its first microsatellite – because of the professor’s concluding remarks:

Prof. Q: [name of Space project] was launched and operated in space for three years, then it failed; we don’t know why.

Interviewer: Oh, I didn’t know.

Prof. Q: It happened, it happens [chuckles]…Yes, 2002, it failed, it just stopped working…One night it stopped working, we don’t know why.

I was also left wondering what had happened to the young university researcher, the MEng graduate from the Space Lab who had flown to the USA with the academic group to witness the satellite launch there in 1999, and who, when interviewed in 2000, had said, ‘If things don’t happen here, I will go to America.’

So when the opportunity arose in early 2007 to find out what had happened to the Space Lab and also to this young master’s graduate of 2000, whom I shall call M, it was with great interest that I set up an interview with one of the Space Lab professors (who had not been interviewed previously).

Interview with Prof. R: Early 2007

From my interview with Professor R at the beginning of 2007, it was pleasing to find considerable stability and even progress in the Space Lab. Good news, too, was that M, the young master’s graduate, had not gone to America. Rather, Prof. R reported that M had assisted in lecturing the black telecommunications students in the PD in satellite-linked engineering soon after 2000. Thereafter, ‘as one of our smartest [name of Space project] students’, he had been recruited into the Space company, where in early 2007 he was still working in the science park as a company engineer, alongside numerous ex-graduates from the Space Lab who were now also employed in the company.

Other ‘positives’ gleaned from this interview, and from the Space company website, were that the company had nearly doubled its staff to about 90, with engineering–science graduates comprising almost half of these – as in 2005. The four ex-Satellite phase 1 professors, who after 2000 had become involved either part- or full-time in the company, were still also active in very similar ways in the Space company – as previously reported for 2005 – and one of the other two (of the original six) had also increased his involvement in the company research activities. At the same time,
the latter professor was now also, in early 2007, heading up the Space Lab in the department – clearly sustaining roles across university and company. Moreover, a bid had been put in to the NRF for this lab to be awarded the funding and status of a CoE in the next round of such awards. And as a small but important element, the Space school science project was still going just as strongly, run from an office within the university.

Nonetheless, it seemed that in the Space Lab, Prof. R’s research work, together with that of some other departmental academics within his research subgroup, was now focused around aeronautics (flight control) and that, overall, the components of microsatellite research had decreased significantly relative to other areas of focus. This was in part due to the Space company now undertaking much of the satellite work in-house with its own engineers. But it also raised new questions: to what extent had the satellite research of the 1990s been more PAR rather than UIBR? And for this engineering department, including its Space Lab, had basic science research components not been as strongly developed as compared, for example, with Frederick Terman’s projects at Stanford after 1945 – where he had managed to achieve a strong symbiosis between engineering and physics?

I wondered about this issue, too, when Prof. R informed me that he had faced certain issues with his NRF rating after the satellite launch of 1999, primarily because his research was regarded as generating insufficient ‘new knowledge and international review’. But this also made me ponder: what does such an NRF rating system signal to others in South Africa? – that you should avoid building a satellite with 40 master’s and four PhD graduates if you want to be regarded at our universities as a ‘good engineering academic’? This whole issue of the balance of UIBR and PAR, especially within research groupings of our engineering departments, is a complex one in relation to South Africa’s specific S&T needs. This dilemma, which surely also affects a vast number of other use-oriented academics in the country – in law, medicine, business, the social sciences – will be explored further in Part 3.

Other issues were touched on briefly in the interview with Prof R: that the university had reduced its percentage holdings in the Space company; that restructuring of the previously almost entirely white-owned and -managed company had been taking place on account of black economic empowerment legislation and concerns; that the South African Space Agency and the South African Council for Space Affairs had become umbrella bodies associated with satellite developments. Another interesting development was that the DST was now providing national funding for the training of postgraduates in satellite work, including in this Space Lab.

Despite these changes, it seemed – at least during the 2007 interview – that there had not yet been a clear, sustained and integrated government support programme for post-2000 research in satellite work, causing the research work linked to Satellite phase 2 to be considerably less developed than had previously been anticipated within the Space Lab. So all in all, South Africa’s R&D in satellite technology seemed still relatively underdeveloped in 2007 – despite its now valuable, non-military use
in such wide-ranging areas as weather forecasting, monitoring marine resources and tracking droughts and other ‘greenness’ for agriculture, and so forth.\textsuperscript{75}

**Concluding summary**

The robustness of the network of four to six professors, and their Space Lab rooted in one department, that I had observed across the years 2000–2005–2007, caused me to rethink the two models (Model A and Model B) I had theorised during the phases of analysis after the first interviews of 2000.

As noted in the Introduction to Part 1, it began to emerge during the second and third phases of interviews that here was another model. I eventually hypothesised this as ‘Model C’ and identified this grouping of a network of professors as a (virtual) centre type for in-depth analysis. As will be seen in the discussions of Cases 8, 9 and 10 in the next chapter, such networks or ‘agglomerations’ of four or more professors, who linked together their individual research subgroups into a network of cooperation comprising what I have termed a ‘virtual centre’ of professor-colleagues, were found to constitute a relatively solid and viable mode of organisation for UIBR and PAR work.

As noted in the analysis above, the network of professors in the Space Lab based in one department was able to reproduce itself over time. When one of the professors became dean, and one or two others shifted much of their work into the commercial enterprise of the Space company after 2000, other professors (and postgraduate students) of the same department were able to step in and continue the research programmes. In addition, the synergy between the university Space Lab and the science park Space company seemed to work quite well. This appeared to be certainly in part due to the underlying philosophy that ‘it is important to keep the two roles [of university and company labs] separate’. Moreover, it seemed that the Space Lab could provide flexibility with respect to research niche areas: when a shift was required after 2000, away from satellites alone and into broader fields such as aeronautics, a subgroup of academics of this department was able to facilitate this realignment of research focus. Thus, in many ways, the virtual centre structure of professors in the Space Lab provided not only academic robustness, but also research flexibility. And, crucially, the departmental infrastructure provided, both directly and indirectly, significant financial, technical and administrative support.

Of course, the Space Lab (virtual) centre was not without problems. The mix between its work of UIBR and PAR was always a complex one; and it would be of interest, if the application for an NRF-funded CoE for the Space Lab bore fruit, to assess whether a shift in the overall research orientation towards the UIBR pole began to take place.

The ideas and questions raised by Case 3 will be pursued further in the next chapter, in relation to those cases where different centre-type research groupings, which I conceive of as lying in between the ‘traditional’ Prof. Science model and the new Agriculture Centre or Space Lab models, are explored and analysed.
Notes
1 The reader should refer back to Figure i.3 (Introduction to Part 1) and Figure 3.2 (Chapter 3) for graphic illustration of the internal organisational structure of the ‘traditional’ (virtual) unit classified as Model T.
2 This mode of organisation of PBR has existed in South Africa since the emergence of research at the first universities in the late 1800s (see Cooper & Subotzky 2001). However, as noted in Chapter 3, this form of ‘research of discovery’ did not exist, even in Prussia, prior to the early 1800s – it became the ‘German tradition’ only during the first half of the nineteenth century. Hence, at times in the analysis, the term ‘traditional’ has been used in inverted commas.
3 As mentioned in the Introduction to Part 1, all cases are provided with pseudonyms to preserve anonymity (see Appendix 2 for details). It can be noted that this research grouping operated in the context of a natural sciences department of one of the research-intensive universities, but the exact subfield of research of Prof. Science is not given here, again in order to preserve anonymity.
4 Some of the first-phase interviews were done by me, and some – like this one – were done by research assistants. All interviews were taped and transcribed (see Appendix 1). It should also be noted that in all 11 case studies, almost all directors as well as senior researchers were male; for this reason, the term ‘he’ is used throughout (also to highlight the ‘maleness’ of the research demography at senior levels) – except in the very few interviews where it is relevant to identify the gender of the interviewee.
5 As noted in the Introduction to Part 1, during the first phase of interviews in 2000, our interviews frequently utilised the term ‘applied research’.
6 I am indebted to Dr Alexandra Hofmanner (see Appendix 1) for undertaking this dynamic first interview with Prof. Science.
7 See also the discussion in Chapter 1 of arguments for the ERA by Pavitt (2000) and Dosi et al. (2006), with respect to the essential role of PBR.
8 Similar views about research being underfunded nationally also emerged, quite explicitly, from over half of the professors heading the other 10 cases in this study – all of which involve more use-oriented research. This was at times quite vehemently expressed, as will be seen.
9 For Prof. Science, and only for him, I undertook no second interview in 2005, because informal contacts revealed no significant changes since the first interview.
10 See especially Cases 5, 6, 7, 8 and 9.
11 The reader should refer back to Figure i.3 (Introduction to Part 1) and Figure 3.3 (Chapter 3) for graphic illustration of the internal organisational structure of the new (real) centre classified as Model A.
12 The dynamics of Case 1, and the factors enhancing or impeding its use-oriented research work, arise from its research focus within the broad field of agriculture, with much of its agricultural research work undertaken in the specific area of biotechnology. Despite the general principle of anonymity adhered to here, it is necessary to indicate these broad features of the case in order to prevent possible misinterpretations of some of its research and organisational dynamics. The specific agricultural sector (e.g. fruit or wheat or wine or
cattle) in which Case 1 undertook its research is not revealed here; instead, the general term ‘agri-sector’ will be used throughout.

13 Officially the Agriculture Centre was designated as an ‘institute’ by its university – like a number of ‘centres’ at our universities where, for various reasons, the more prestigious term ‘institute’ is assigned (e.g. to enhance international status, since in some countries the term institute is used for such research centres, as discussed in Chapter 3). Nonetheless, as I shall argue, it clearly functioned as an exemplar of a Model A ‘centre-type’ structure, according to the categories proposed in Chapter 3.

14 The basic structure of the Agriculture Centre outlined here was derived partly from its website information accessed in 2000, and most importantly from insights derived from the interviews and documentation, including a slide presentation which the director kindly provided to me later in 2000. I am indebted to Dr Sharman Wickham in particular, who during that year undertook a set of two in-depth interviews with the director of this centre as well as one interview each with two of its senior researchers.

15 Figures 4.2–4.6 relating to the mission, structure and funding of the Agriculture Centre have been adapted from the documentation kindly made available by the director in 2000.

16 In late 2004, during the second phase of interviews, it was found that two of the four seniors had been promoted to associate professor level within the academic department, effectively recognising their research status and function. In some countries (e.g. the UK) the term used is ‘senior research fellow’, but I prefer to use the term ‘associate professor-researcher’ to highlight the need for this crucial layer to be theorised and organisationally consolidated at this level within new research centres – for example, within the new national NRF-funded CoEs (discussed in Part 3).

17 It should be noted that use-oriented research, based at laboratories of the university of the Agriculture Centre, had proven itself over many decades as a valuable contribution to this region’s agricultural industry, including the specific agri-sector which was the focus of the research done by this Centre.

18 Interview in 2004 with a senior officer of research administration at the university.

19 This information was gained from an interview in 2004 with a senior research administration officer at the university. The generally high level of tertiary qualifications within this Industry Network is also reflected in a comment during my 2004 interview with the executive director of the Network, that ‘…there is not a single [agri-sector] industrialist sitting on any of my [Network] committees who does not hold at least an undergraduate degree, often a BSc Agriculture, and quite a number hold master’s degrees’.


21 This information was gained from the 2004 interview with the executive director of the Industry Network.

22 Other grants in 2003 included, for example, those for researchers based at another Western Cape university, and even as far afield as the University of Pretoria and Rand Afrikaans University.

23 This was stressed in the interviews with the director of the Agriculture Centre in 2000, as well as by the executive director of the Industry Network in 2004.
For example, in the second phase of interviews, in late 2004, the new director of the Agriculture Centre mentioned that one of their post-docs had been contracted to write a special quarterly column for one of the farmer magazines on their biotechnology research, and that the magazine's section on 'farmer technical issues' included regular articles by Agriculture Centre researchers. Importantly, too, all project-funding contracts with the Agri-Sector Industry Network included a condition that each research grant holder should seek to publish at least one article in an academic journal and one article in a popular publication, to facilitate dissemination across a wide range of audiences (from Industry Network website, accessed May 2004).

As will be seen, this difference pertains also to Case 1 in comparison with many of the other cases which follow (except the real centres exemplified by Cases 6 and 7), since most of these had not consolidated a Model A centre-type structure like the Agriculture Centre of 2000.

Although the senior researchers were designated ‘permanent’ (Figure 4.4) and most held senior lecturing posts in the academic department, the majority were funded primarily via the Industry Network and therefore held ambiguous positions, since such funding was not entirely secure over the long term. This became important when the director departed in 2003, as is described later.

At this and many other South African universities, the postgraduate student FTEs of a research unit or centre counted towards the FTE total of the department to which it was linked, so that de facto the additional FTE students for this academic department helped in its negotiations for extra lecturing posts.

This information was gained from my interview with a senior officer of the research administration of the university. It should be noted that work hours in the Agriculture Centre, as for most researchers in the other use-oriented research groupings investigated, usually extended into numerous evenings and weekends per month.

This could be viewed as a promotion, since there were over 90 researchers at the overseas research institute, as well as greater research opportunities. However, it seems that a near-mugging incident experienced by the director shortly beforehand also affected his attitude. This information was also gained from the interview mentioned in the previous endnote.

As noted earlier, some R10 million had been donated by the Industry Network in the mid-1990s for the start up of the Agriculture Centre: about half of this funding went to infrastructural costs including laboratories, and the remainder was invested to enable some researchers' salaries to be paid annually from the interest earned. But by 2003, some of the invested capital was being depleted due to a shortage of salary funds. This information was gained from an interview with the executive director of the Industry Network in 2004.

See the Introduction to Part 2 for details of the THRIP and BRIC initiatives.

All the data for the period 1996–2005 were obtained from a special brochure published by the Agriculture Centre for its 10th anniversary. Data for 2006/07 came from the third phase of interviews.

This information was obtained from my 2007 interview, the company website and the documentation cited in the previous endnote.

This is my assessment based on information from the interview with Associate Prof. W of the Agriculture Centre.
A number of spin-off companies arising out of research based at this university, including
the spin-off company of the Space Centre of Case 3, came under the umbrella of this
university holding company.

The follow-up visit in early 2007 also revealed that one of the Agriculture Centre professors
had applied for an NRF Research Chair award, which would enhance his research teamwork
within the AD-AC structure.

As argued for the Agriculture Centre in 2000, the role of basic or what they called
‘fundamental’ research in molecular biology and allied disciplines had always formed the
core of their work, and this had continued right up to 2007. This was also stressed across
the research examples of their work given in their 10th anniversary brochure, despite the
growing components of PAR as well.

See the discussion in Chapter 2 and Figure 2.2 with reference to what I term the
‘Investigation Work Spectrum’, where I classify certain (non-research) work including
routine testing as ‘routine consultancy’ work.

In 2006, some Centre senior researchers had nonetheless undertaken a series of roadshow
presentations to groups of agri-sector farmers and industrialists about the controversies
around genetically modified organisms, following debates and features in the popular press.

The reader should refer back to Figure i.3 (Introduction to Part 1) and Figure 3.2
(Chapter 3) for graphic illustration of the internal organisational structure of the new (real)
unit classified as Model B.

In fact, Prof. Genes often seemed to be directly accountable to the senior management of
this HEI rather than to the dean of Science or the Science Faculty Board (see later).

Most of these support staff became part of the off-campus company that was set up (see later).

This information was derived from written documentation kindly provided by Prof. Genes
in 2000.

Many of the 11 had no formal structural underpinnings other than the ‘traditional’ rules
pertaining to a research unit or lab led by a senior professor, formally accountable to the
head of department, as in Case 0, or to the dean of the faculty as in Case 1 in 2000.

Description on the unit’s website, quoted from a newspaper article on this unit (for reasons
of anonymity, exact references are not provided in this section).

Information from company website, accessed October 2000.

These grants were administered by the NRF (see Introduction to Part 2).

Information derived from documentation and the website of the Genes Unit in 2000. When
the second and third phases of interviews were conducted, it was found that the high level of
international publications had continued to 2005 and beyond.

In 2000, the director was supervising about 10 master’s and doctoral theses in this subfield.

The Genes Unit obtained postgraduates from the neighbouring, more research-intensive
universities, as well as from further afield.

For reasons of anonymity, this newsletter will not be cited, and this applies also to other
sources mentioned in this and the next few paragraphs.
This new national network, funded by the DST, was established after the first phase of interviews. For reasons of anonymity, the name of this network is not provided here, and it will be referred to as the government national network.

Details of personnel movements were kindly provided in interviews with the director and one or two others of the Genes Unit, as well as obtained from documentation and website information (including names and dates of appointment of personnel) for the Genes Unit and the GNN, and the latter's various university node activities.

In an interview in 2005 with one of these researchers at the neighbouring university, this hypothesis was confirmed by the interviewee, who was already significantly involved in some undergraduate and honours postgraduate teaching, which provided a feeder for students into their new master's programme.

See Kruss (2008) in the follow-up study of this company, which forms part of her broader study of three university-linked companies.

The reader should refer back to Figure i.3 (Introduction to Part 1) and Figure 3.4 (Chapter 3) for graphic illustration of the internal organisational structure of the new (virtual) centre classified as Model C.

For reasons of anonymity, the field of engineering is not specified.

This information was obtained from the website of the Space Lab research group accessed in May 2000 (the exact reference details here, and for all the references which follow, are not provided in order to retain anonymity).

An interview much later, in 2007, suggested that one reason for NASA support had been the positive orientation of the USA State Department to this 'peaceful' microsatellite development in South Africa in the 1990s. This included an ANC-government agreement to a non-military reorientation of the satellite structures based at a site in the Western Cape, where some military R&D work had previously been linked to the apartheid government's military programme of the 1970s and 1980s. (This installation – see further later – at Houwteq near Grabouw became known under the new ANC government as the Institute for Satellite and Software Applications.)

Information obtained from my second interview with an engineering professor of the original project in March 2005, and from the departmental website accessed in December 2005.

Information from a 1999 article authored by some of the Space Lab professors.

From historical documentation kindly provided by some of the interviewees.

The Space project itself used official names for the Satellite phases 1 and 2.

During the course of the project, a grant of R5 million was obtained from a company for a Chair linked to space research, thereby enhancing this research and its associated postgraduate teaching in the department over the medium term.

This description of the core elements of this teaching philosophy is derived from an article by the core group of Space professors (1996), and from interviews with three of the professors.

It should be noted here that, although new higher education funding formulae since the late 1990s have increased funds for the training of master's and doctoral students via a 'research'
component (for completed theses) and FTE enrolment subsidies, these formulae have not included any subsidisation or incentives for multi-skilling via research projects such as this Space project programme.

67 Again, this national school project did have an official name.

68 Data provided at the time of the interviews in 2000. The Space school science project was still running in 2005 when one professor interviewee mentioned that by then, possibly 200 000 schoolchildren had been exposed to this project.

69 Data from an interview with one professor and from the website of the Space company, accessed during 2005. In what follows here, only some of the main features of the company are outlined.

70 The university company was a holding company for a set of corporations such as the Space company which had come together over the previous decade, all linked to use-oriented academic research at this university.

71 Information from Space company website, accessed January 2005.

72 An earlier portion of this interview is given in the Introduction to Part 1.

73 The term ‘interlinked’ is used here, and sometimes in later cases, because when the full publication listing (from the Space project’s original 1990s website) was reviewed, and also from interview discussions, I came to realise that it was difficult to separate out satellite work that might be classified as UIBR from work that was PAR. It seems as if during the 1990s PAR – directly applied research for a problem solution in context, for example a specific mechanism for that satellite – was considerably more dominant during the actual construction of the satellite. As an example, too, the 40 master’s theses produced during the Satellite phase 1 far outnumbered the four PhDs, with the latter focusing especially on ‘new knowledge production.’ Another indicator of this initial dominance of PAR was, perhaps, the potential loss of NRF rating faced by one of the Space professors just after 2000 – because of the absence of significant international publications. This professor commented during his 2007 interview (discussed later) that he ‘didn’t learn much more new engineering in this [Space] project.’


75 For discussion of further developments, and some challenges, faced by the satellite commercial–industrial enterprise at this university later in 2007, see an HSRC study which involved follow-up interviews and documentary analysis of this company later that year (Kruss 2008). See also the subsequent DST (2008) ‘Ten-Year Innovation Plan,’ in which ‘space science and technology’ was selected as one of the major national challenges.
Case studies of research groupings in between the traditional Model T and the new Models A, B and C

The seven case studies presented in this chapter are analysed in less detail than the four cases of Chapter 4. The aim here is to focus mainly on the factors enhancing or impeding the development of use-oriented research work within the seven groupings. In each case study, I argue that the most fruitful way of understanding their dynamics with respect to these factors is to view them as cases essentially in transition from the structures and cultural norms embodied in nineteenth-century first academic transformation practices, rooted in PBR, to those of the new second academic transformation driven by a third mission and UIBR/PAR. I argue, too, that to understand the underlying factors enhancing or impeding this transition, it is essential for each case to be investigated with respect to its core internal structure or mode of organisation.

Figure 5.1 is presented as a guide to understanding how the seven ‘in between’ cases described in this chapter relate to the research model typology introduced in Chapter 3, and to Cases 0, 1, 2 and 3 in Chapter 4. The research groupings that lie between Model T and Model B in Figure 5.1 are Case 4: the ‘Biogenetics Unit’ and Case 5: the ‘Commerce Unit’; those between Model T and Model A are Case 6: the ‘Sustainability Centre’ and Case 7: the ‘Fluids Centre’; and those lying between Model T and Model C are Case 8: the (Virtual) ‘Centre-as-Department’, Case 9: the (Virtual) ‘Centre-in-a-Faculty’ and Case 10: the (Virtual) ‘Centre-as-Agglomeration’.

Figure 5.1 Cases in between traditional Model T and new Models A, B and C
Research groupings in transition between Model T and Model B

This section examines two cases in which individual professors were, I argue, attempting in various ways to make a transition to research structures embodying more use-oriented research; the cases highlight the complicated nature of these different paths of transition towards the third mission of contributing to socio-economic development. Both cases revolve around individual professors and their relatively small research groupings and in many respects, both of them exhibit internal characteristics observed in the new (real) unit of Prof. Genes in Case 2, and therefore also in the 'traditional (virtual) unit' of Prof. Science (Case 0) (Figure 5.2). I have named the two professors here ‘Prof. Biogenetics’ (Case 4) and ‘Prof. Commerce’ (Case 5) to broadly reflect the academic focus areas of their work.

Figure 5.2 Research groupings in between Model T and Model B

Case 4: Prof. Biogenetics – in transition between Model T and Model B

Prof. Biogenetics was located in a department of a faculty of science in one of the research-intensive universities. He¹ was selected for interview because his CV² showed considerable involvement in industrial applications of research in his ‘lab’.³
Nonetheless, the interview of 2000, and the follow-up interviews in 2005 and 2007, revealed how firmly this professor still held to the importance of undertaking components of basic research in his subfield of biogenetics, thus highlighting the complex combination sought in ‘the lab’ of underpinning the industry work with high-quality fundamental research. In essence, therefore, I would argue that UIBR formed a strong platform for all of this professor’s laboratory work.

It emerged from the interview in 2000 that Prof. Biogenetics had attained a doctorate in South Africa numerous decades earlier. Thereafter, a few years as a post-doc at a leading overseas university had provided a grounding in biogenetics – just at the time when applications of this field of research were emerging within the international academy. Thus, when he returned from abroad, he became one of the first academics working in this area at a South African university. This work continued during the 1980s, and it included some PAR in an area lending itself to industrial applications. This more applied orientation was further intensified during a spell as director of a science council research unit. But, unhappy with the more ‘commercial, research consultancy’ direction taken by the science council, focusing on PAR work for industry, Prof. Biogenetics departed and took up a position as head of an academic department of a university in the Western Cape. He was still located there when the interviews for this study took place.

In the interview of 2000, Prof. Biogenetics explained that, at the Western Cape university, he continued with the type and structure of laboratory which he had directed at the science council. At the same time, he continued with numerous industrial consultancies which had begun from the time of his return from abroad (with such consultancies also providing important additional funding for the lab work). Thus his professional history shows an academic career of a number of decades in which there was a complex mix of UIBR and, sometimes, PAR, all linked to publications by Prof. Biogenetics and his postgraduates in internationally accredited academic journals.

A small group research structure – like Prof. Science

Despite these links to industry and some consultancies, it was clear from the interviews that the way in which research was organised by Prof. Biogenetics was very similar to that of Prof. Science (Case 0) with his PBR. Prof. Biogenetics spoke about his ‘research group’, describing it as a fairly loose structure within the department, with this professor, at least one post-doc, and a collection of around 10 doctoral and master’s students working on theses linked to the group’s niche area of research. The department comprised a number of such groups or ‘labs’ working in different areas, and fairly frequently another professor in the department would join this group to link with some of their research projects and to assist with student supervision. In the 2000 interview, Prof. Biogenetics stressed this more flexible idea of a group: ‘So, we are a group; we don’t have to call ourselves a unit. We know who we are. But there is no advantage in calling ourselves a unit and it can be more harmful than good.’
He later explained that this ‘harm’ could arise, for example, by drawing overly sharp boundaries between those who were in a unit and those who were in other groups in the department. He also mentioned that their group actually comprised two or three small subgroups or teams, each working in a different area.

So although this research group (my lab) was more use-oriented towards industry than that of ‘traditional’ Prof. Science (Case 0), it nevertheless had almost the same internal structure of core personnel as that of the Science (Virtual) Unit. Moreover, it also seemed that this mode of functioning enabled Prof. Biogenetics to supervise his lab at a distance – leaving a post-doc or academic colleague of the department in charge on a daily basis, while he fulfilled various other academic roles required by the university. For example, for well over a decade, while directing the laboratory, Prof. Biogenetics had not only served as head of department but also as deputy dean and as chair of a number of very senior university committees, as well as serving on numerous other national academic associations and advisory bodies for government. In 2000 (and at the time of the later interviews, too) a considerable number of undergraduate courses were also part of the standard teaching load for this professor.

As already mentioned, a post-doc researcher (I will call him P) was recruited to run the lab when the professor could not be there. This is how Prof. Biogenetics described it:

I do spend a lot of my time supervising students, but ‘one step away’. P does the day-to-day. I do the bigger picture and the management. But when anything comes – like we want to do field trials – I run those because I have all the contacts...And certainly my next step is to start a company.

He commented further, ‘I have got lots of contacts and I travel a lot. But I do rely on my graduate students to feed me the latest. Particularly now that I have been writing my book...’

Admittedly, attempting to combine all these roles, including forming a company and writing a book (both linked to use-applications in his research niche area), was complex and there was a danger that things would get out of control. The post-doc researcher, P, who had been assisting Prof. Biogenetics, was later appointed as a tenured lecturer in the department. He had been playing a vital supportive role, but was intending to leave in 2005. This was causing some anxiety for Prof. Biogenetics. But before looking at the situation of 2005 during the second phase of interviews, it is important to explore a few other central elements which emerged during the first interview.

Moving to form a company in 2000: ‘Alongside and within’ the academic laboratory

During the interview of 2000, the discussion with Prof. Biogenetics raised another major issue emerging from his current research – the idea of running a proposed new company, to be pursued alongside the writing of books for primarily professional, non-academic audiences both nationally and internationally.
As described in Chapter 1, there seemed to be a clear drift, internationally, towards an increasing commercialisation of university academic research after the 1980s, especially in areas of biotechnology. During the first interview in 2000, it was therefore interesting to find that there also seemed to have been a clear drift in Prof. Biogenetics’ research with respect to greater opportunities for commercialisation. These shifts included a series of specific industrial applications of the research outputs of this research group, as well as the patenting of some of these by the professor. Moreover, at the time of the 2000 interview, these developments were culminating in an attempt by Prof. Biogenetics to form his own commercial company, in order to market the research products more effectively.

Interestingly, Prof. Biogenetics’ laboratory, which was firmly located within the department, was seen in 2000 as the basis of both the company and the more fundamental research:

Interviewer: Does that mean that the [research] group you have at the moment will be turned into a company?

Prof. Biogenetics: No, I’m not sure that’s a good idea. I think that the model I have will be that the people who work in the company will be graduates so they will come through our system and they will be wanting jobs. I don’t see PhD students being involved in the company. [But] they will all be working in the same labs. Physically they will be the same but they will just be reporting to a different department and have different agendas. One will be writing a thesis. The other will be producing a product. Those have to be clearly separated…

Elsewhere in the same interview, Prof. Biogenetics said:

There is a huge step between what you do in a lab with graduate students and what you finally commercialise…If it works in the field, the next step is to transfer those [named discoveries] into [name of some of their industrial products]. It’s difficult, but it is not intellectually challenging. There’s nothing new in it. So now it has to go into the next phase. It’s not the phase of a university. It has to be a company that is funded to do routine type of work, lab work, to bulk up the numbers to get all that. I’ve been in contact with an outfit called [name of a new venture capital company in biotechnology research] and they support incubator companies [like the one he was planning] with management skills, marketing skills, intellectual property skills, etc.…

In 2000, Prof. Biogenetics thus perceived a sharp difference between, on the one hand, what was in effect UIBR (something ‘new in it’, PhD students ‘writing a thesis’ but with potential applications in mind) and, on the other hand, routine contract work by a company (‘not intellectually challenging’, ‘producing a product’ for marketisation). At the time of that interview, Prof. Biogenetics had the idea that both types of work could happen in the university laboratory, but that the
researchers ‘will just be reporting to a different department’ (academic supervisors rather than a company) ‘and have different agendas’ (theses and journal articles as opposed to commercial products). So the framework seemed to be well formulated.\textsuperscript{7}

When the second interview was undertaken in 2005, I thus expected to find the proposed company up and running, alongside the well-established UIBR work in Prof. Biogenetics’ lab.

From industrial company to international publications: Moving back in 2005 towards UIBR

When I undertook the second phase of interviews in early 2005, I was surprised to find that internationally published books, and not the company, had become Prof. Biogenetics’ priority. He had gravitated more strongly towards the UIBR side of the research spectrum, rather than moving further towards the more industrial, company-linked applied research; the 2000 proposal to form a commercial company linked to his departmental lab had not become a reality.

Extracts from the second interview provide insights into some reasons why this had not happened, and why the books and allied conference and congress presentations had become a priority:

Interviewer: What’s happened commercially? – because you were talking [in 2000] of forming a company.

Prof. Biogenetics: I actually…the former head of [the university commerce school] and I were very great friends, and he actually loaned me a senior lecturer to help me write a commerce plan…And we spent about a year [around 2000]…planning it and writing it.

Interviewer: This was a company?

Prof. Biogenetics: Yes. And then the more I heard about it – because I then went to hear lectures from people who had started companies…But I remember one guy who started a company at medical school. He said, ‘Ja, I started it because I didn't have a social life anyway.’ And I thought, you know, ‘Am I a little old for this? You know…I think you might have to be twenty-two and with fire in your belly!’…and then a very interesting thing happened. I was invited by [name of senior member of a leading international organisation], via the head of the American Academy of Sciences, to address the [name of a leading international organisation] two, three years ago, 2002…[about his first book on the role of biogenetics and applications in the Third World]…And the reason I was invited – there were many reasons, really, but one of the chief reasons – I had no links to an industry. And I thought, you know, what I’m doing is too important. I’m actually a goodwill ambassador, right around the world, for biotechnology and for Africa. And if I am in any way tainted [with industry]…I’ll lose my credibility. And of course since then, it’s gone from strength to strength,
you know, I get invitations, I mean, I turn down more invitations than I can accept…

And much later in the discussion:

Interviewer: Are you still doing a lot of – the sort of international journal publication?

Prof. Biogenetics: Yes, [mentions some journal articles] […] and […] I’m writing my second book now [extending the argument of the first book].

Clearly, a major reason for this relatively senior professor not forming a commercial company linked to his lab was the potential threat it raised of harming the credibility of his academic research through a (perceived) association with industry. This echoes the concerns, discussed in Chapter 1, of many academics from Sweden and other countries who felt ambivalent about trends towards the second academic transformation and its potential for academic research directions to be driven by the interests of big corporations. In the Western Cape, these same issues were being faced. And they seemed, at least partly, to have caused Prof. Biogenetics to move backwards, refocusing on UIBR and on resulting international academic publication.

It should be noted that, in part, Prof. Biogenetics’ books and allied presentations were oriented towards a non-academic professional audience – people concerned about the implications of biogenetics in relation to biotechnology and societal development. Therefore one element of his work was making the research outputs of his lab available, at least in part, to civil society groups and organisations. These outputs were thus being disseminated beyond the university, outside of the usual U–I–G triple helix framework.8

What about the mode of organisation of the research group of the Biogenetics lab: had it changed from 2000 to 2005? The 2005 interview showed that the core internal structure – of professor, postgraduates and a few post-docs – had remained unaltered over this period. Post-doc researcher P (who was already a lecturer in the department in 2000, and who had been promoted to associate professor by 2005) had remained part of the research grouping, and was serving as a vital coordinator of the lab work for Prof. Biogenetics ‘at a distance’. Yet the interview also revealed that P was about to take up an important position (with a 90 per cent buyout)9 elsewhere in the country, as the biotechnology research leader of a government-sponsored industrial development network in this subfield of research. This could clearly lead to an element of instability within the research group.

The idea of establishing senior research fellow positions, without lecturing duties, for research labs in this university had been suggested at one point in the 2005 discussion, by the interviewer. This was the response:

Prof. Biogenetics: I’ll tell you: with P leaving, your idea of [this university establishing] a forty-year-old researcher [i.e. what I as interviewer had described as a senior research fellow position]…would be really fantastic.
Interviewer: How are you going to deal with it [P’s departure]?

Prof. Biogenetics: I’m going to travel less… I’m concerned about the future, and you know, taking P out 90 per cent of the time, in four years’ time you might find a different [i.e. more problem-filled] picture here.

So, while Case 4’s de facto ‘traditional’ internal lab structure seemed more stable than many other cases (for example, the Agriculture Centre of Case 1, and the three new ‘virtual’ cases which follow in this chapter), it too could, under certain conditions, slide into a state of some instability if more senior research fellows or other lecturer-colleagues did not link up their research with that of Prof. Biogenetics. It was therefore with some interest that I revisited the Biogenetics Unit in 2007.

Early 2007: A further interview with Prof. Biogenetics

The degree of stability of Prof. Biogenetics’ small research group (lab) was highlighted during my visit in early 2007; this stability was primarily linked to his solid location as a professor within an academic department.

In this follow-up interview Prof. Biogenetics recalled that his post-doc, P, after becoming an associate professor in the department – and still linked to his lab in 2005 – had left for a research position outside the Cape. In 2007, P was no longer directly involved with research or postgraduate supervision, because of heavy commitments in his new job. Yet, thanks to adequate funding, Prof. Biogenetics had employed two highly competent new post-docs who were coordinating the work in the lab. In addition, the professor had linked up some projects with the research work of two other senior academics in the department, thereby mutually strengthening all their lab work (including some joint postgraduate supervision). In this way, intra-departmental cooperation enabled valuable synergies to take place. Moreover, one of these senior departmental colleagues had just been awarded an NRF research chair, which Prof. Biogenetics noted would indirectly enhance both his own research work and research in the department as a whole.

In terms of the idea mooted in 2000 of Prof. Biogenetics forming a spin-off company linked to the laboratory research work, for the same reasons outlined in the 2005 interview he had not pursued this any further by 2007, and it did not seem to be a possibility for the future. Prof. Biogenetics had published a second book – mainly for professionals interested in the debates about genetics and biotechnology linked to his niche area of research – and he mentioned in this 2007 interview that he hoped to produce more such works in the future.

Not only was Prof. Biogenetics’ work of authoring and conference presentation continuing but, in addition, he was now also chairperson of a major government advisory committee on biotechnology. Thus his work with civil society professionals and public audiences was now being extended into work with national government ministries, by means of chairing a vital government committee. His role on international bodies with respect to biotechnology was also expanding.
These national government and international advisory roles were substantial; moreover, Prof. Biogenetics’ goal was to maintain a steady output of international peer-reviewed journal publications. He also mentioned that an option had recently emerged of heading a newly proposed research centre at the university, relating to a niche area of biotechnology, but added that he did not find this idea particularly attractive. The unspoken question seemed to be: why take on the directorship and administration of such a large centre? (It was to be linked internationally to some other centres, and joined internally within his own university to some research subgroups in this niche area across a few faculties.) He felt that his own ‘little science’ group of around 10 postgraduates and two post-docs, informally linked to two other academics in the same department, was just as productive and less problematic than the proposed larger centre.

A question thus remained in my mind for later interviews: what were the advantages and disadvantages of large centres when compared to smaller units?

In conclusion: Prof. Biogenetics had had opportunities to move into more directly applied research and ‘routine consultancy’ links with industry, and even to form his own spin-off company, but had chosen instead to retain his focus around UIBR.

As noted earlier, there is thus no automatic trajectory for academics, within the unfolding second academic transformation, to link up with industry rather than with government or civil society; nor for such academics to drift slowly and inevitably towards the more directly applied research and routine consultancy side of what I have termed the ‘Investigation Work Spectrum’ of research. Nonetheless, given the substantial financing available from industry and commerce, there are strong pressures on some academics to take on not only PAR work, but also some routine consultancy – as shown in the next case study.

Case 5: Prof. Commerce – in transition between Model T and Model B

The historical lack of research culture at technikons

The dynamics of this case – the first to be examined with respect to a university of technology (UoT)10 – must be located in the context of the historically generally weak research culture of technikons in South Africa. I will show that this culture had significant effects on Prof. Commerce’s own PAR orientation, which often drifted in an unplanned way into ‘routine’ or ‘non-research’ consultancy. This historically weak technikon research culture will also be seen to give rise to associated problems that are having a serious impact on the practices of many UoT centres and units, including those examined in Cases 7, 8 and 9.11

During the entire interview period from 2000 until early 2007, Prof. Commerce was the head of a department in the broad field of commerce studies at a technikon which, during this period, underwent a merger with another technikon.12 During this period he also headed a committee coordinating research for various departments involved in commerce studies at the institution. Thus, at the time of the
first interview in 2000, he and the technikon leadership viewed his role as important in trying to drive forward a new culture of research in the commerce studies division of this HEI. Yet he had to deal with the legacy of a technikon established as a teaching institution in which the three-year National Diploma qualification was central. Prof. Commerce put it this way in the first interview:

When I got into the technikon in 1993 it was like most technikons; the culture was very much an extension of high school. You were judged on contact time and pass rates. You taught…[But in the last few years] there has been a definite swing towards technikons becoming more and more involved with research, mainly because the National Research Foundation strategy to have a special technikon [research] programme had different criteria [e.g. number of publications, niche areas of research], and they were screaming for people to submit [research] proposals.

Thus, both internally – driven by technikon leaders and some senior academics – and externally – driven by the NRF and even some sectors of industry and other stakeholders – pressure on technikon lecturers to undertake research had increased by the late 1990s. The new degree-awarding status of technikons, through the new B.Tech degree (introduced at fourth-year level after 1993), was also affecting this transformation, as was the encouragement of qualification by postgraduate thesis work for the master’s-level diploma and doctoral-level laureatus (a few years later renamed the M.Tech and D.Tech respectively). Yet in 2000, Prof. Commerce said that his role as research coordinator of this grouping of commerce studies departments was not easy:

[The technikon leaders] have given us the [research coordinator] portfolio but not the resources to go ahead with it…We have a faculty research meeting every month and I am still involved with the policy on that…We have agreed to have a two-day breakaway workshop only on research…[The technikon senior research director] has a year schedule of slots on a Friday afternoon where research training is given [for academics, on supervision, proposal writing, etc., but] they are not well attended – it’s the start of the weekend!

By 2000, therefore, one potential way of enhancing research within this grouping of commerce departments was to appoint a research coordinator and to organise research meetings, workshops and seminars. Another important approach, as outlined in a newspaper article about this commerce division, was to create a ‘research unit’ (as it was termed in his division) around which all use-oriented research in this division would be clustered:

[This] research unit examines real-world commerce problems…[It was] established two years ago [in 1998] with the purpose to initiate, promote, develop, conduct and support its entire staff and all its students in industry-related research.
There was, therefore, an attempt to drive forward research among this grouping of departments by creating what they called a type of ‘research unit’ structure – but essentially it was a network of fellow academics within the commerce division, around which all research activity would be clustered. Thus in this first interview with Prof. Commerce, it was not clear how this could be anything more than a cluster of academic staff conducting research with the encouragement of Prof. Commerce (as the de facto chairperson of the research committee of this division) – rather than what I have termed a Model B type (real) unit directed by a professor-PI.

As a final pointer to the problems of historical research culture at the UoTs, it is useful to quote some of the positive and negative aspects of this culture described by Prof. Commerce in the interview of 2000:

There are only a handful of academics in [our division] who are keen on research…[but] it is improving…[and] we had fifteen master’s students this year. For us that is brilliant. We are moving…One of the big restrictions for research is time. We have massive classes and we have a lot of [teaching] contact time. When it comes to examination time the poor lecturers are up to their ears in marking. There is no time for research…You are always asked to do something and the admin within the department per lecturer is mind-blowing…I can’t consult now. I have to do it at night, on weekends, or very early in the mornings and then nip out and see a client quickly. I always arrange to do my [off-campus] presentations for a Friday afternoon. Clients expect that.

Potential drift from PAR to ‘non-research’ routine consultancy

Prof. Commerce’s comment about research and teaching consultancies with clients reflects an interesting theme which also came up in a number of other cases, and is an important one at both UoTs and universities. It concerns the issue of potential drift from PAR into ‘non-research’ consultancies; it also relates to a question raised in previous chapters about the need for an artificial wall to be constructed between academic work within a university, and more routine investigation work at sites outside the university. This problem refers back to the comments of a professor from the Space Lab (quoted in the Introduction to Part 1) who argued that, in order for good academic research to be preserved, such a wall was always needed between the academic research grouping and the industrial clients being served through its use-oriented research. It should be recalled too (see Chapter 2), that this was a significant issue of debate and conflict at MIT – itself a path-breaker in industry-linked research work – as early as the 1920s and 1930s, arising in relation to consultancy work.

In Case 5, it emerged from the first interview with Prof. Commerce that he had been undertaking two important projects with clients. These projects were linked to his UoT teaching areas as well as to his previous work experience. Before joining the UoT, he had had over a decade of experience in both local government organisations and private industry, and he carried this resulting knowledge into his commercial
studies teaching at the UoT. His two most recent projects with clients were also linked to these areas of expertise.

Two questions might be considered in this case, and with respect to most other university research projects which lie on the PAR side of the spectrum. The first question is: to what extent does the project fall within the niche area of teaching or research expertise of the academic? In the case of Prof. Commerce, the investigations at the heart of both projects did initially fall broadly into the academic area (of commercial studies) but, because the investigations were driven by the clients, the research work in both projects began slowly over time to ‘spread out’ considerably beyond the niche area of specific expertise of the academic involved.

The second question is linked to the first: to what extent is there a real research component – work that could be classified as ‘new knowledge production’ in terms of the *Frascati Manual* definition of research (OECD 2002; see Chapter 2 endnote 4) – in these projects for clients? Admittedly, any investigation work must, to some extent, surely produce something new, even in a relatively trivial sense. So perhaps this question might be posed from a different angle: to what extent is there specific academic expertise being applied, which could not be done at least as well by a (non-researcher) consultant based outside an academic environment?

In the next section, these issues about the nature of PAR as distinguished from more routine consultancy work – especially at UoTs, where use-oriented research of a more applied nature is often predominant – are followed through in relation to this case, for 2005 and beyond.

Five years after 2000: Questions of research culture and consultancy

A follow-up interview with Prof. Commerce in 2005 was oriented towards understanding how the research culture within his division of commerce studies had developed in the interim, and finding out whether his project work had moved towards ‘non-research’ consultancy rather than ‘new knowledge’ PAR.

It appeared from this second interview, and from annual research reports of this division since 2000, that building a research culture within departments previously oriented to undergraduate teaching was proving extremely difficult. During the 2000 visit it had emerged that fewer than one-tenth of the academic staff in this division held a PhD, and that those staff who were undertaking research were doing it primarily to attain a higher qualification (either MTech or DTech) in relation to their job position.16 The strategic plan for the 2001–05 period for the research cluster of Prof. Commerce’s division had set a goal of 33 per cent of staff registered for doctoral studies by 2005, but this had not been achieved. Moreover, although a few staff had presented papers at conferences each year, the division (with over 50 academic staff) had produced only a small number of accredited journal articles17 during the five-year period after 2000. Prof. Commerce was among the top producers, with two such articles during this time. The main research thrust within this division was the supervision of about
20 MTech minor dissertations per year (following the completion of students’ master’s coursework), although even here well under 10 had graduated.

In terms of Prof. Commerce’s own research work since 2000, he had undertaken a series of consultancies, including at least two projects, which had produced major reports for the clients. Nonetheless, it was observed that at least parts of each project had fallen considerably outside the specific niche areas of his academic field. With regard to the other projects, he commented:

I’ve done tons of consultancy work [since the first interview in 2000]…It’s training – developing training manuals for mainly [local] government, and doing equity plans, doing strategic planning for firms and that type of stuff. Been doing a lot of that – which is not [primarily]\textsuperscript{18} research.

Importantly, although Prof. Commerce usually supervised five MTech minor dissertations each year, he did not generally link these to his consultancy work, preferring to work alone, sometimes with a secretary as assistant and occasionally with past master’s graduates. I questioned him about this:

Interviewer: And in the MTech: have you had any students doing their master’s or BTech projects linked in any way [to your consultancies]?

Prof. Commerce: No, unfortunately I don’t use my [master’s] students because I don’t have the time to check everything; because it’s not for their development, it’s a client who wants a product at the end of the day – it’s commerce.

He did mention sometimes using one or two past students: ‘They like doing it, they’ve been my students and they’ve been out of my department for ten years, so they’re mature.’

Later in the interview Prof. Commerce noted that what had really expanded after 2000 had been teaching work for clients, that is, utilising his expertise for external training:

Look, I do a lot of training. Last week I did three days training at the [centre in Cape Town] for industry, on project management. And I’ll most probably go up next week for three days and do something at the [name of centre] in [an area of Gauteng]; the [name of a science council] wants me for five days. I’ve got another five days with the [name of] municipality coming up at the end of November…

In summary, therefore, it seemed clear that research, even PAR, had not expanded much within this division of commerce at this UoT. Nor had Prof. Commerce developed a significant thrust into in-depth PAR in his specific niche area – including output via accredited journals. Instead, he had continued with his consultancy projects, spreading across a broad range of areas for governmental and industrial clients. More importantly, there had been significant expansion by this UoT academic into external education and training workshops for a range of
clients – industry and government, and even broadly for civic organisations such as local government – utilising the broad expertise acquired in teaching in his commerce field, as well as the work experience gained prior to joining the UoT. This alerted my study to the potential role of UoT research work with respect to social responsiveness to local civil society, and – perhaps even more importantly – of the social responsiveness role of tertiary teaching programmes and workshops. The servicing of such teaching needs for civil society, alongside use-oriented research work, will be considered more broadly in Part 3.

Thus, during the five years after 2000, Prof. Commerce had exhibited energetic and innovative utilisation of teaching and consultancy expertise in a broad area of commercial studies, for commercial and civil society clients outside the campus. But there had been no serious enhancement of PAR work in his own niche area of disciplinary expertise, partly because the consultancy work had been spread across a very wide canvas – including also into ‘routine’ types of work which many non-UoT consultants could have undertaken quite easily. In other words, there is suggested here the danger of a second academic transformation leading to a proliferation of consultancy work outside the specific expertise of an academic concerned.

Early 2007: Follow-up interview with Prof. Commerce

My interview with Prof. Commerce at the beginning of 2007 indicated that he was now head of the two (corresponding) departments of commerce studies spanning the newly merged UoT. He had, however, stepped down as research coordinator of the division of commerce, giving way to a new chairperson of a merged research committee. But in this interview it seemed that, at least on Prof. Commerce’s old campus, the person now overseeing research in their division was putting even less emphasis on research:

We have a newly-appointed research coordinator for [name of his campus], subordinate to the combined committee [for both campuses], who is more teaching-focused as opposed to research.

Thus it seemed, at least for the commercial studies division on this campus, that the 1999 strategic plan for developing a research culture among a section of the academic staff had not materialised in a significant way.

Nonetheless, the durability of the model of a lone professor (assisted by secretary and past students) undertaking consultancy work was still evident. In other words, his own small de facto Model B-type Commerce Unit, with himself as PI together with one or two assistants, was still functioning with respect to his use-oriented work in 2007 – showing again a transitional movement from a Model T-type structure, to a similar Model B internal structure (Figure 5.2) but with strong focus on third mission activities. In the final interview, Prof. Commerce expressed the desire to increase his accredited publications in order to attain full-professor status at the UoT, linked also to an NRF rating. Moreover, he was continuing with a variety of consultancies and his off-campus teaching work had continued to expand, proving
the viability of UoT-oriented courses for civil society and especially for industry: 'But the contracts for training in industry, that’s gone way up [for me]...the workshops and the training...yes, that’s increased.’

In conclusion, all this again raised the question for me of whether each UoT could develop a strong, albeit limited, set of niche areas in PAR; this seemed clearly possible in Case 5 with respect to this innovative Prof. Commerce – as long as a more direct focus on his specific area of research expertise was pursued instead of more diffuse consultancies. It also highlighted the issue of these institutions playing a strong social responsiveness role, allied to PAR responsiveness, in off-campus teaching of workshops and courses needed by industry and civil society organisations.

Research groupings in transition between Model T and Model A

Figure 5.3 Research groupings in between Model T and Model A

The dynamics of the next two case studies, Cases 6 and 7, suggest that they were each in the process of forming a new Model A centre-type grouping. I see these two
cases as thus in transition from a Model T-type structure of ‘little science’ to that of a Model A larger (real) centre type (exemplified by the Agriculture Centre – Case 1 in 2000 – analysed in Chapter 4). It is my hypothesis that many of the problems they encountered are best understood by examining them as variants of Case 1, and my exploration of their respective modes of organisation will be related specifically to the core internal structure of this case as highlighted in Figure 5.3.

Case 6: Sustainability Centre – in transition between Model T and Model A

Case 6, called here the Sustainability Centre, highlights the problems experienced by a creative and innovative research grouping which had developed many of the core features of Model A as exemplified by Case 1 (the Agriculture Centre) – director and co-director, research subgroups, postgraduates and centre-type administrative infrastructure, linked to a research programme on issues of ‘sustainability’ in relation to external ‘clients’ (Figure 5.3). Yet the Sustainability Centre lacked a crucial component: a very solid layer of senior researchers heading its research subgroups. (This layer was conceptualised in Chapter 4 as the level of ‘seniors’ or ‘associate professor-researchers’ within a centre-type grouping.)

It will be argued below that the roots of the fragility of the Sustainability Centre go back to its origins: the way in which it emerged, in the mid-1980s, from the interdisciplinary postgraduate school established a decade earlier.

Origins as an interdisciplinary postgraduate school with an applied research focus

After obtaining his doctorate overseas in the early 1970s, the founder professor of the Sustainability Centre, Prof. Sustain, returned to fill a new chair in an emerging new field focused around ‘sustainability’. The position was endowed by a large company, at a time when this field of study was just gaining international academic recognition and policy relevance – including for industry. The moment thus seemed opportune for the creation of an inter-faculty ‘school of sustainability’ at the university concerned, headed by this professor. Its focus was to be on a new coursework master’s and academic research, short courses for professionals and others, and some outreach activities through applied research, including policy and contract research work; in other words, components of PAR were there from the beginning, alongside UIBR and even some PBR within the school (discussed later).

However, a crucial change occurred in the mid-1980s which, I argue, gave rise to the fragile state of the research grouping – which continued right up to the time of the third phase of interviews in 2007. With only the professor and one other tenured staff member, this inter-faculty school – or de facto ‘postgraduate department’ – of studies focused on issues of sustainability was struggling in the early 1980s, as recounted in the 2000 interview:

Prof. Sustain: [The school] couldn’t handle the demand. We had very high demands [for the master’s programme and contract research] and we said
the university must decide: either we are going to grow [as a larger centre],
or there must be formal relationships with departments so we could get the
lecturing staff we needed.

The university's decision was for the school to join up with an allied academic
department. Prof. Sustain became head of the merged departmental entity, and
the one other tenured member of the school joined the new department too. This
new department undertook all undergraduate and postgraduate teaching, with the
postgraduate curricula incorporating the school's master's programme – which
continued to have more than 10 students per year right up to the interviews of 2007.
Research that the university viewed as 'higher-level' (published in peer-reviewed
journals) was undertaken primarily by departmental tenured staff.

Prof. Sustain had a dual role, as head of the new department and director of what
the university now called the new 'research unit' – the grouping which developed
into what I have termed the 'Sustainability Centre'. The senior researchers were now
located in the new department. Those who remained in the 'unit' (located in a physical
space within the academic department) were contract researchers, mainly with
master's-level qualifications, who continued with some of the research orientation
established by the previous school – substantial PAR projects for industry, policy
formulation and reviews for government and other contract research work for civil
society organisations. As time went on, the Sustainability Centre also significantly
expanded its short-course professional training and policy research work, which had
begun under the auspices of the erstwhile school.

This 'solution' in the mid-1980s effectively split the more 'academic' functions of the
new department (teaching and more basic research) from what were viewed as the
more 'applied' functions of the newly constituted 'research unit'. This division was
embodied in a dichotomous governance structure: the academic department was
responsible to the Faculty of Science and its dean; the research unit was formally
responsible only to the university research committee.23 This lack of a home was an
important factor in determining the fragility of the Sustainability Centre.

I would argue that this solution in the mid-1980s was not the only one possible
at that time. The university could have decided to expand the school as a purely
postgraduate-cum-research academic 'department' – a 'postgraduate research
school' – with the necessary increase in the number of tenured academics.24 But this
was not on the agenda at this university – nor was such a structure contemplated
there even in 2007. In fact, such schools have been discouraged at this university
because 'the department' was conceived of as the essential core undergraduate-cum-
postgraduate structure25 – a notion which, interestingly, is in accordance with the
conceptual framework of the first academic transformation.

Another solution would have been to transform the school into a Centre of (Research)
Excellence, with its primary emphasis on UIBR but with some postgraduate
functions as well, and again with more tenured research staff. But here too, even
in the recent period, such an expanded concept of CoEs – including postgraduate teaching and administrative functions – has not yet begun to emerge as part of the academic discourse at this university.

It will be hypothesised (in Part 3) that options such as these may not become a significant part of academic discourse until the second academic transformation and third mission are fairly well established across the South African ‘elite’ universities – which was hardly the case at this university in the 1980s and 1990s, or even in 2007.

I would also hypothesise that, at its inception in the mid-1970s, this new school of sustainability studies emerging under Prof. Sustain was part of an academic discourse (international and local) which still viewed use-oriented research primarily as PAR, rather than as UIBR – the latter being a concept that has only been developing clearly since the late 1990s and after. In fact, in its early days (1970s–80s), the move towards what was seen as ‘applied’ research work by the school – and subsequently by the Sustainability Centre – was progressive and even innovative. It was nonetheless relatively oriented toward the PAR side of the research spectrum, what Prof. Sustain described in his interview of 2000 as ‘problem-oriented’, for example pollution control for a specific company.

From the discussion during the interview, however, it became apparent that this was not mere ‘routine consultancy’ work, but rather applied research *embodying considerable elements of new knowledge* through data collection, sometimes within a modelling framework, in other words, incorporating also what some might term components of UIBR.

After the mid-1980s nonetheless, the core research work of the Sustainability Centre continued to be oriented towards the PAR side of the spectrum, through specifically focused consultancies for clients. In addition, professional training in issues pertaining to this new field of study, via short courses, was important for the Centre, and became even more important in the 1990s. Conversely, what many in the university viewed as ‘normal’ research (oriented towards peer-reviewed publications and including also some policy research work) and almost all of the teaching (undergraduate and postgraduate) was siphoned off into the adjoining academic department. Moreover, the Centre had to raise all its own funding – as clearly outlined by Prof. Sustain:

> So that [the consultancy work for clients] became essentially the main thrust [of those in the new unit, from the mid-80s]...The responsibility for students [including the teaching of postgraduates] came to the department; the department carried that. But when it [the new unit] was set up [as part of the merging of school and department], it was set up as a self-funding unit. Quite clearly now the staff [one or two from the previous school] that moved to the academic side were funded by the university. But the unit has to cover all its own costs.

Flowing from these funding constraints was the internal staffing structure of what developed as the Sustainability Centre. Essentially, by the 1990s it consisted of
untenured researchers with mainly master's-level qualifications. The next section highlights quite starkly the problems deriving from this situation for the Centre, as well as the underlying message that funding is fundamental – to all research units and centres. This will be argued in more detail in Part 3.

Short-term contracts: The situation in 2000 and thereafter

With the international emergence of a second academic transformation and third mission across many research-intensive universities, a range of issues have emerged with respect to contract researchers. There are enormous and expanding numbers of contract researchers within the new research centres and units – with unstable, insecure and often poorly remunerated posts, working alongside the tenured academics (usually researcher-lecturers) who are a historical product of the first academic transformation. This was noted in Chapter 3, and here the phenomenon will be explored further with specific reference to the dynamics within the Sustainability Centre.

From the emergence of the Sustainability Centre as a formally defined research grouping after the 1980s right up until early 2007 when the third phase of interviews was undertaken, only the director held a tenured position within the group. The next most senior researcher (also later the co-director) was a woman, who obtained her master's (with distinction) in the postgraduate programme of the school just before the merger with the academic department in the mid-1980s. She then became a contract researcher associated with the research unit and obtained her PhD under the supervision of Prof. Sustain in the early 1990s, and – after a short time away from the unit in the 1990s – finally became its co-director just before our interviews in 2000. Yet even she was still in an untenured post – despite having been made co-director – when I interviewed her in 2005. In other words, she had effectively been a contract worker for 21 years (though there were changes from 2007, which are described below).

It must be stressed that this was not atypical of the 10 use-oriented research groupings investigated here, although this highly motivated and extremely competent co-director was the most long-standing holder of a contract post whom I encountered. As she put it in her first interview in 2000:

So I was employed by the unit on a contractual basis [from the early 1980s]. If work was needed and I had the expertise, then I would do the work. But, at the same time I was also raising funds, independently, for research projects which I routed through the unit, so I was almost acting as an independent agent at that time. They didn't pay me, I raised my own funding to ensure that my salary was covered.

At the time of the first and second interviews in 2000 and 2005, this researcher, as co-director, was managing the fund-raising and coordination of the Sustainability Centre. Its staff composition had roughly doubled since the early 1990s but its mode of organisation – fairly similar to Model A – had remained the same. Besides the
two co-directors, in 2005 its core internal structure comprised six researchers all with master's degrees, and four research assistants/interns mostly with honours-level qualifications – 10 non-senior researchers in total. These were supported by an administrative infrastructure of three persons. This core of 15 people was therefore similar in shape to that of the Agriculture Centre in 2000. However, the members of both the researcher and administrative layers of the Sustainability Centre were less highly qualified than those in the corresponding layers of the Agriculture Centre (whose senior researchers and post-docs all held qualifications beyond master’s level) – not least because the Agriculture Centre had been able to depend on its much better resourced agri-sector industry for funding.

Much of the contract research work done for clients of the Sustainability Centre was thus carried out by these fairly junior researchers – extremely committed and hard-working, but none of them holding a doctorate.27

Some of the more experienced researchers at the Centre, including the co-director, helped to teach parts of certain modules on the departmental master's programme in this field of study, as well as supervising some of the project work and mini-theses of these students. A continual source of tension, over two decades, was that this teaching and supervision done for the department by members of the research grouping was paid, not at the Centre's standard hourly consultant rates, but at typical university rates for tutors. Postgraduates and research assistants helping with academic teaching and supervision at low rates was viewed by the university as the norm – developed internationally over more than 100 years and linked, as I have argued, to the nineteenth-century first academic transformation.

From the 1970s, and continuing right up to the start of the third phase of interviews, the Sustainability Centre ran a series of professional short courses for government, industry and civil society groups and individuals on issues in this field. What had begun in the mid-1980s as an annual two-week professional course run each December, became especially important for the Centre's work and reputation.28 Equally important was research and development consultancy work for civil society groups such as community organisations, local government bodies, trade unions and other activist groupings – growing in the 1980s and 1990s, and ongoing after 2000. Just before 2005, however, their ‘advisory unit’, specially set up in the late 1990s for such purposes, linked to engagement with civil society, had to close – mainly because of problems experienced in raising donor funding.29 It must be stressed that the Sustainability Centre was the only one of the 10 use-oriented cases studied which was found to have a significant civil society side to its research work. The spirit and mode of this commitment is well captured in a comment made in 2000 by the co-director:

You know that's perhaps where we [in the Sustainability Centre] are slightly different from maybe mainstream academic departments, is that we're trying to be more practical, more relevant, and to produce materials that are also of value to the broader community...we might have one paper in a refereed journal. But we're producing reports, we're producing pamphlets, we do a lot of work in communities. And obviously we have to
charge different rates there…for example we've just been asked to develop [name of their research field] guidelines for the Gugulethu [a Cape Town township] community…they've got a limited budget so a lot of our time is going to be free basically, but we want to do it.

Finally, it should be noted that in 2005 researcher numbers in the Sustainability Centre were not much higher than they had been in 2000. The most experienced contract researcher at the Centre (apart from the woman co-director) – a white male researcher who had gained a master's degree in sustainability studies from the department in the early 1990s and who had joined this research grouping before the 2000 interviews – had just left at the time of the second interviews in early 2005. His experience in the Centre is instructive and is presented in some detail below.

2005: The reluctant departure of a key contract researcher

During the second phase of interviews in early 2005, I approached this white male researcher, whom I now refer to as ‘ER’ (experienced researcher), for an interview from the vantage point of his new position as a private consultant outside the university. He provided very valuable insights into the problems faced by many university-based contract researchers, in his case for nearly a decade before 2005, and his comments highlight some of the reasons why research groups like the Sustainability Centre are so often fragile and unstable with respect to retaining their core research personnel.

In the interview in 2005, researcher ER looked back positively on his time at the university:

Firstly, I think it's a very nice environment to work in, [name of university], you're sort of surrounded by academics and the richness of the debate...[In the late 1990s] I left the so-called private sector [as a corporate consultant, to join the Sustainability Centre]...One of the reasons I thought I wanted to come back [to the research unit] was to think of doing a PhD.

But he also outlined some of the difficulties of trying to work on a PhD and compose journal articles, while at the same time completing research consultancy reports for the Centre:

Interviewer: What was the main focus of your work?
ER: …basically everything, you know, all our consulting ended up usually in a report – that's what we produced...

Interviewer: For the client?
ER: For the client, ja...the frustrating part was within those reports there were one or two research papers sitting there, potentially. But once the
project came to an end, the payment for that work was finished. Because we didn’t have the university salaries, we weren’t being subsidised by the university who'd say ‘Okay, now, here, take the month off for whatever… take it out and write the research paper.’

And much the same applied with respect to his PhD:

ER: [I had hoped to] take the information out of that [longer project] to write up a PhD, which certainly there were possibilities to do that…or you could do it after hours. But, I mean, the crux, I suppose, still comes down to a situation – that final write-up for the PhD – is that you need to take up six months or something, and the [name of Centre] certainly didn't have a sabbatical policy...If someone had given me a year and said, ‘Okay, now go and write it up,’ with a little bit of hard work it might have happened. But the model's not there [for such time off]…our salaries weren't being paid by the university, they were being paid by ourselves [from client funding].

Later in the interview, ER mentioned that often, in the years before he resigned from the Centre, he and the co-director had discussed various schemes and models to overcome some of these problems. The policy of the Centre was that projects had to raise 1.5 times the researchers’ salaries:

My argument was, you know, the more you pay me, and as long as I cover my costs, the more I bring into the unit. So if you pay me R30 000 a month, I’ll have to bring in R45 000, so you get R15 000 out of me, as opposed to R10 000 [if he were paid his existing salary of R20 000 and brought in R30 000] – so there’s extra money, which makes commercial sense. And [names of the two co-directors] understood the logic there. But when you go to the university, they’ve got their salary scales [for non-tenured researchers], and they look at it and they say, ‘Well, firstly, where you are [at R20 000] – you shouldn’t be at that level, you don't have a PhD in the first place.’

So the normal remuneration system of the university, based in essence on the first academic transformation notion of the lecturer-researcher as the building block of academic salary scales, was unsympathetic towards ER's proposed new scheme. Nor was the university responsive to putting forward their own funds for another scheme:

And another scheme [suggested by researchers of the Centre] was that the university cover 1.0 or 1.5 of a post to the [Centre], based on its teaching and other contributions…We put the report [scheme] together…what [the co-director] was saying [to the university] was: if you’ve covered that [new post] for one or one and half of our salaries, then we would allocate three months to [this researcher, for time off], three months to [names of co-director and some other researchers in the group], et cetera – and you would, say – in those three months – you [each] produce a [research] paper. And it would have been fine.
Yet, just before 2005, the unit was reviewed by its university research committee and questions were asked about where the real research was in the Sustainability Centre’s work – this in the climate of the new NRF national rating system for researchers, based primarily on peer-reviewed publications in local and especially international journals. ER continued:

When [this university] had that review of all academic departments and units, about a year or so ago, one of the criticisms that came up with the [Centre] was ‘Where are your papers?’…So the criteria with which the university was judging the [Centre] was very much on academic sort of criteria.

Interviewer: Who would pay for the time to do that [peer-reviewed publication work]?

ER: Well, that’s the catch-22 situation.

These difficulties appeared even more intractable when contract researchers compared themselves with what they saw as a trend among tenured academics within departments:

You see, the model here…the discrepancy between full-time academics and our second-class academics [the contract researchers] just keeps on growing and growing…You [pointing to myself, the interviewer, a tenured academic] are allowed to consult, so you’re allowed to boost your salary every month by private work…as you become more senior as an academic [tenured] – that’s obviously depending on how good you are and what you do and the type of person – the potential for augmenting your salary increases all the time, so the gap between this person [tenured] and this person [contract researcher] salary-wise can be quite great…You see, in this model here, there’s no real reason why the Prof. in academia has to leave. They’re getting their salaries [and then augmenting this][but contract researchers] can’t do private work because they’re self-funded in the model [of the Sustainability Centre].

This researcher made it clear that he would very much have liked to remain part of the Sustainability Centre; he was doing valuable teaching and contract research and community-linked policy work:

I enjoy teaching…we gave the practical, the application of the theory back into the master’s course – which for [name of a subfield of sustainability] management is quite important. So it wasn’t just that – this is the theory of [name of subfield again] – we could come in with case studies of work we were doing. So it was almost – this is where best practice is at the moment.

Later, ER commented on professional short-course training, which had been expanded by the Centre during the previous decade:

This was the time of democracy after 1994, the need for capacity building in government – local, provincial, national training, and that type of stuff.
So [the Centre] moved into that, and they got a very big project from [an American donor agency to do this].

He also commented on the Sustainability Centre's expanding policy and contract community research work for civil society during the previous decade:

Being linked to university you’ve got access to the libraries, the literature, and to academics to thrash ideas out...[The Department of] Water Affairs approached us to develop the model [specific to development policy in the area]... [and] some of the work I’m finishing off at the moment is for the [name of a legal aid group] where, in this case, they’re representing the [name of] community who won a [name of type of] claim.

Despite all this, however, a few months before this interview in 2005, this white male researcher in the prime of his life had resigned from the Sustainability Centre to become a private consultant:

My decisions were largely just driven around financial security...Sure it was a big step [leaving the Centre] – you know, you’ve got three kids, you’ve got a family and you’re going out there on your own...[Yet] at the end of the day, it wasn’t a decision that was difficult...I mean, at [the university] I was literally in the red most months.

After the 2005 interviews: Where to for the Sustainability Centre?

During my second phase of interviews with some members of the Centre in early 2005, there seemed to be a strong awareness that a turning point in this research group’s history was imminent. There had just been a university research review of the Centre, with significant pressure for this ‘unit’ to become more research-oriented with respect to peer review publications. The most experienced researcher had just departed, and the Centre’s long-standing director had stepped down as HoD of the allied academic department and was about to retire from the university and from the Sustainability Centre as well. Other researchers, including the long-standing contracted female co-director, were also contemplating change.

An advertisement had just been posted by the Sustainability Centre for a senior researcher, preferably with a doctorate and over five years’ experience (a position I classified in Model A as falling within the ‘senior researcher’ layer, that is, above the post-docs). ER had argued in his interview of 2005 that this post was unlikely to be filled by such a senior person:

[This advert for] probably about a thirty-, thirty-five-year-old person with five or six years’ experience, preferably a PhD, but at least a master’s – now if that person has been working out in the private sector for the last five or six years, they have salary expectations which are not going to be met by [name of this university].
If no such outsider could be found, would an internal candidate who had just attained a master’s in the departmental programme – or at very best a new PhD graduate of the department who wished to gain post-doc experience (at a low salary) in the hope of getting onto the academic track – be the best appointment for this Centre?

In fact, after conducting the 2005 interviews, it was my hypothesis that another option was more likely, because the situation in the country at that time was not the same as in the immediate post-transition time of 1995, or even like that in 1985, the ‘struggle era’ – the time when the unit had been established, basing its core research work on groups of committed master’s-level researchers and the occasional post-doc. This other option might, I thought, be that the research grouping would shrink and become a ‘research unit in or alongside a department’ (like the Genes Unit), rather than a de facto centre.

These were not the only possible scenarios. It was suggested during the 2005 interviews that significant donor funding for a new director post, and even one or two relatively permanent researcher positions, might still be forthcoming on a long-term basis. It was also suggested that funding might be acquired from sympathetic private companies, because of support for sustainability issues. This was something that had been hoped for by those in the Sustainability Centre for many years. Could such funding stabilise the situation for the Sustainability Centre after the retirement of its original director, without any personnel leaving to join the department?

Early 2007: A follow-up interview with the previous co-director

When the director of the Centre retired from this university shortly before the 2007 interviews, the female co-director applied for an associate professorship in the department and attained a tenured position, while also remaining as the (sole) director of the Centre. The researchers of the Centre had decided, moreover, that, given the salary scales, any advertisement for another director was unlikely to attract a very senior person. In addition, an unknown new director might destabilise the group. So a deputy director (rather than a co-director) who held a doctorate was appointed from among the researchers of the Centre.

However, something unexpected (in terms of my assumed options) emerged during 2006 and 2007: serious activity was taking place in the Centre aimed at building a layer of at least three ‘seniors’ below the new director. In part, this was linked to the third option mentioned above. For although the new director and others at the centre did not hold out hopes of enormous donor funding – large enough to appoint a layer of permanent senior researchers – there were certainly enough funds held in reserve, along with significant new and ongoing large research contracts from government, industry and international organisations, to enable at least three senior researchers to be appointed. One of these would be on a two-year contract and another two on indefinite long-term contracts. So two experienced researchers with doctorates were appointed into the senior layer, together with one of the other internal researchers.
who was just completing a PhD. In addition, a post-doc from another country joined the Centre. So, for the first time since its inception, the Sustainability Centre had five relatively senior researchers (including the director). This meant that it had moved from a structure somewhere in between Model T and Model A, to a situation now much closer to a full Model A structure with a strong layer of seniors.

In 2007 there was, below this layer of seniors, a group of about four researchers with master’s qualifications, and one or two research interns – as well as the same two administrative personnel who had been there in 2000. There were thus, overall, 13 full-time personnel making up the Sustainability Centre in early 2007. This was a substantially more solid research grouping than ever before, because of the new layer of senior researchers.

Moreover, as the new director stated in her 2007 interview, the ‘shift towards research [had] happened’. Certainly, the pressure from the Sustainability Centre’s academic department and from the university itself – particularly after the 2004 review – had played a part in this shift towards peer-reviewed, publication-oriented research. So too had the Centre’s internal ‘rethink’, which had taken place after the founding and long-standing director left the Centre. It was clear that greater value was being placed on UIBR within the Centre as a source of long-term benefits for society with respect to the third university mission of socio-economic development. At the same time, the national climate at South African universities, including an increased emphasis on NRF ratings which especially valued internationally peer-reviewed publications, was also a factor in bringing about this change.

This type of shift towards research had knock-on effects in other areas of the Sustainability Centre’s work. My 2007 visit showed that their long-standing involvement in professional training through short courses – mainly for government and industry professionals – had ended after 2005. Only some smaller, ad hoc requests for such training were being considered. The reasons for this included the fact that one of the three administrators who had coordinated this work for many years was in the process of leaving. In addition, other private organisations and other universities had now grown in competition with this Centre (in the 1970s, it had been the originator of professional training in this field). Furthermore, obtaining sponsorship for such courses had become more difficult. But clearly another important factor was that the shift towards peer-reviewed academic research had effectively relegated such short-course professional training to a less important place – behind UIBR (including policy research) and PAR (a historical priority for the Centre).

Given the increasing involvement of the new director in departmental teaching and management work, and with some of the Centre’s senior researchers playing a greater postgraduate teaching role, the question arose of how the work of the Centre, in particular its substantial involvement with civil society groups, would now be affected.

The fact that the Sustainability Centre had unexpectedly evolved into a more solid and more flexible Model A centre type, with a layer of senior researchers, made
it potentially easier for it to undertake serious long-term research programmes (incorporating UIBR plus PAR) not only for industry and government, but also for civil society organisations. But this potential was crucially dependent on both external funding and an internal commitment to this work (an issue explored more broadly in Part 3). In 2007 the commitment of the Centre’s existing staff to this aspect of the third mission was strong, but the future seemed uncertain.

One point just mentioned, about the central role of external funding, will also apply to the case study presented next, that of the ‘Fluids Centre’ at a UoT. But in this case, it was substantial external funding to facilitate U–I research linkages, not U–CS relations, which was vital in enabling the transition from ‘small unit’ to ‘larger centre’.

Case 7: Fluids Centre – in transition between Model T and Model A

Case 7 emerged in the latter half of the 1990s as a small research grouping within an engineering department at a UoT. Of all the 10 use-oriented groupings studied, this was the one which had most effectively transformed itself by 2005 into a well-functioning Model A-type new (real) centre like the Agriculture Centre (in 2000). During the later phases of interviews it was found to be a relatively large new structure, stable and growing in terms of its research output and number of personnel, and officially recognised as a ‘centre’ by its own institution.

Typical origins as small professor-led grouping: A Model B-type structure

At the time of the first interviews in 2000, Prof. Fluids was head of an engineering department and had built up a small research group (a de facto research unit, with respect to mode of internal organisation), with three PhD students and some 10 other postgraduates, mainly MTechs, working in his lab. At that time it was still termed a ‘research programme’ (rather than a ‘unit’), with a clearly focused research agenda relating to Prof Fluids’ research in a subfield of chemistry-physics-engineering, rooted in PAR work based on contracts for industry.

In 2000 this research grouping was viewed by its UoT leadership as one of two cutting-edge research units at this institution, the other being Case 8. Case 7 as a research group had emerged in the 1990s around industry-linked, use-oriented research driven forward by Prof. Fluids. As will be seen, the Fluids Centre’s Model B-type structure of ‘small unit’ in 2000 clearly reflected fairly typical origins: the departmental chair, or what I term here the professor lecturer-cum-HoD, had built up a small research group around himself (as PI) in the late 1990s, rooted in his lab and comprising postgraduate students whom he was supervising.

What is interesting is that the leader of this grouping, like the leaders of the other two UoT groupings investigated in Cases 8 and 9, had obtained his master’s and PhD engineering degrees at a university. This experience of university research culture, it is argued below, clearly influenced all these leaders-cum-HoDs in their dynamic pursuit of research within their UoT environments.
The professor leading the Fluids Centre nonetheless initially saw his core identity as that of a dedicated teacher – ‘my second love is research, my first love is teaching’ (2000 interview). For nearly two decades he had focused on engineering science teaching at the undergraduate level, at which the vast majority of UoT students were enrolled.35

His supervision of student research projects as part of the new national four-year BTech, which was introduced in the early 1990s, acted as a catalyst for the emergence of his research activities in the late 1990s. His attainment of a PhD degree at a neighbouring university by the mid-1990s was also important, as was the UoT’s encouragement of the development of MTech and DTech degrees from the late 1990s. Thus by 2000 he found himself supervising 20 master’s and six doctoral theses (most of the latter were UoT staff seeking higher qualifications). Parallel to this largely unplanned growth of his research supervisory activity, other research opportunities began to emerge. The stimulus for this was a request from a firm of two engineer friends, who had attained doctorates with him at the university, to embark on a research consultancy with them for a mining company, in their joint engineering subfield of research involving chemistry-physics. The success of this research project, which combined contract research for industry with academically stimulating problems and, moreover, yielded significant research funds, led to the growth of his own department-based research laboratory in the few years up to 2000.

The nature and structure of this small research grouping in 2000

In 2000 Prof. Fluids and three PhD students essentially composed the core of his research grouping. At that stage, as noted, it was called a ‘research programme’ rather than a ‘unit’ or ‘research centre’ (which it had formally become by 2005) on its website and in advertising brochures. It is important to explore its prevailing nature and structure at the time of the first set of interviews, because a very important transition in internal structure had taken place by the time of the second interviews of 2005. As discussed in the next section, by 2005 this research grouping had officially incorporated the term ‘research centre’ into its website name and, more importantly, this reflected how the professor and grouping conceived of themselves and structured their work. By 2007, moreover, a further name-cum-structural change was being envisaged, namely to ‘institute’.

The internal structure which had emerged by 2000 was typical of the organic evolution observed in numerous cases above, when a professor begins to build a small research grouping around himself within a real or virtual lab or group of a department. In this case, typical of UoTs at this time, there were no post-docs in Prof. Fluids’ research programme: the three core researchers were all his PhD students, who began to consolidate their work in a chemical-physical field of engineering problems experienced in industry. Since one of them, researcher-lecturer A (a senior lecturer in the department), had had a number of years of industrial R&D experience prior to beginning undergraduate teaching at the UoT, he was a valuable asset. So too was B, another researcher with prior industrial experience and a completed engineering master’s thesis in an adjoining department, who joined Prof. Fluids’
department as general laboratory manager (including overseeing the professor’s own lab work) and also embarked on a PhD thesis under his supervision. Finally, just at the time of the interviews in 2000, the professor made an important breakthrough: he secured C, with a master’s degree from a university abroad and with a background in physics and allied subfields; furthermore, he had persuaded the UoT leadership to create for her a new type of post classified as ‘researcher’ within his programme, without teaching duties. As Prof. Fluids said in 2000: ‘This is a big step forward for me and our technikon. Nobody has ever been appointed as a full-time researcher in this institution. This is real ground-breaking stuff here.’

Because both researchers B and C did not have significant amounts of teaching duties in 2000, nor right up to 2007, their unique positions will be referred to throughout this case study as ‘researchers B or C’ – to highlight what was a very unusual phenomenon across all 11 cases.

The funding for this research programme, including the funds for part of researcher B’s work and all of C’s work, was mostly derived from national, and even some international, mining and other industry research contracts for work in their niche area. In this specific research niche there was very little expertise at that time in South Africa, other than that of Prof. Fluids himself and his two engineering colleagues with their Cape Town-based firm. Total industry-led funding grew quickly to nearly R5 million by 2000, with a small portion derived from the NRF (previously the FRD). The latter were happy to support, via their emerging (late 1990s) Technikon Research Development Programme, this professor who was showing promise and was one of only a small number of UoT researchers to have attained an NRF/FRD research rating at that time. NRF/FRD support was important despite most funds deriving from industry, for, as Prof. Fluids put it in 2000: ‘That [about 10 per cent NRF portion] is my foundation. That is what I stand on. Industry funding is at times very fickle.’

He explained that not only was some of his industry funding unreliable when companies faced a bad year but, moreover, his public status as a recipient of NRF rating and funding enhanced the confidence of industrial firms in his research programme.

The interviews of 2000 with Prof. Fluids and some of his researchers revealed an excitement and creativity about research, clearly linked to the sudden growth of a research grouping inside a typically teaching-oriented department of a UoT. Their research, driven by industry contracts, seemed to fall primarily within the category of PAR, although a UIBR component was sustained as well, which developed up to 2005 and especially beyond (see below).

Yet the interviews also suggested that this research grouping was facing significant problems at the time. Discussion of these problems took place during the first set of interviews during which in fact we mentioned ideas about the second academic transformation, and the shift internationally at universities towards more use-oriented industrial research and also more ‘centre-type’ research structures. This later led to
my research associate (who had been the main interviewer for Case 7) being invited to act as facilitator-cum-discussant at a workshop held by the research group in 2002. During this workshop they discussed their problems and considered the way forward. Some of the main problems articulated at this gathering of the whole group were:

- the problems arising from the professor leading the research while also serving as HoD;
- the problems of some of the researchers bearing heavy teaching loads;
- the problems of a weak research culture at UoTs, including in their department;
- the problems of having an unclear career track for researchers within the group.

A big transformation by 2005: Emergence of a new (real) centre of Model A type

By the time of the second-phase interviews in early 2005, big structural changes had taken place within the previously small research grouping or unit. This development was in part stimulated by concerns which had already emerged in 2000 and which had surfaced at various moments of the workshop review just noted; it was also influenced by my own and my research associate’s comments to Prof. Fluids about the value of a new and larger centre-type organisation.

One important change was signalled in my interview with researcher B in 2005: he informed me that towards the end of his doctorate (completed in 2003), he had accepted a tenured academic position to lead a research unit at another HEI, because his position as an annual contract researcher within Prof. Fluids’ research grouping was so tenuous. Immediately, the UoT, led by a supportive vice-chancellor and other senior officials and following long-standing exhortation by Prof. Fluids, offered him a new research post with tenure. Promotion to senior researcher category came with his attainment of the PhD, and this new research post required very little undergraduate teaching; instead, his role was to lead his own subgroup of researchers within the Fluids Centre, which in 2005 comprised his one PhD and five master’s students, as well as some fourth-year BTech students helping with specific projects. Moreover, when asked whether post-docs would be valuable to his subgroup, he answered in 2005: ‘Yes absolutely! That would be the next step… [say] two post-docs.’

His new contract required him to raise a portion of the research funding for his subgroup or team from industry contracts, as well as from the NRF and other sources. Clearly, therefore, a subgroup structure like that of the Agriculture Centre (Case 1) was emerging, in which senior researchers such as B led a subgroup of researchers focused on a respective sub-programme of research based on their own specific expertise, under the overall direction of the professor-director of the Centre.

Other steps taken after 2000 all helped to transform Case 7 from an informal small-group research programme into a Model A structure, a new real centre. These steps included Prof. Fluids and researchers A, B and C reducing their involvement in departmental teaching, and focusing instead on research activities, including running their own research subgroups; their seniority in the department also
increased as they attained their PhDs. Prof. Fluids also stood down as HoD and his prime role became recognised as director of the officially designated ‘Fluids Centre’.

Prof. Fluids appointed two further researchers who supervised some master’s students while also undertaking research for their doctorates. Importantly, too, the Fluids Centre acquired support staff comprising two full-time administrative personnel, one part-time laboratory technician and one full-time IT technician, and a laboratory manager who had been appointed from industry after 2000 in order to release researcher B from this task.

Clearly, in terms of the international comparative analysis of Chapter 3, Case 7 was making a transition to a larger research centre mode of organisation, typical of the second academic transformation and its associated third mission. Nonetheless, as will be seen from the overview of the case studies in Part 3, this transformation was the only successful one out of 10 use-oriented cases, thus highlighting the current difficulties of achieving such a transition to ‘real research centre’ in our South African universities.

Funding for a transformed Fluids Centre

During the period after 2000 when the Fluids Centre was undergoing this transformation, the role of NRF funds linked to its Technikon Research Development Programme became more important, as was some support from the UoT itself, although industry research consultancies, including some THRIP funds, still provided major funding. The funding from these diverse sources enabled the construction of a large laboratory for experimental work in the niche area of research in which the Fluids Centre specialised. This multifaceted laboratory not only enabled numerous new contracts to be signed, but was also an impressive and visible sight to all visitors and potential industry clients, who could be taken on a walking tour of its different spaces. Moreover, as Prof. Fluids put it during my interview of 2005:

> So it's superficially a commercial service to industry...[but] actually what it is [the large laboratory], it's a foot in the door. The guys [industry] will come and ask us for [specifies laboratory testing of material in their niche area], and we say, ‘Why do you want [such testing], what do you think it can do for you?’ Then we slowly build up a relationship with them and then say to them, ‘Alright you could do much more in the process if we were able to help you with this, and this [i.e. more long-term and extensive research investigations of their process], and sell them our services, give them a competitive edge...we can do that.

In terms of research orientation, therefore, I would argue that the Fluids Centre had clearly found a way to use the strengths of its researchers and postgraduates, grounded at a UoT, in order to focus on the more applied end of the research spectrum rather than directly competing with neighbouring university-based groups, whose strengths often lay more in UIBR. Nonetheless, it was asserted in a
number of interviews that there also needed to be a basic research component to their investigations. As researcher B put it in 2005:

So you need to derive empirical equations based on experimental results... ultimately you want to derive equations, you know, from a more fundamental point of view... It's quicker to get the experimental results and feed it into industry. But ultimately you try to understand it.

During the interviews in 2005, I observed that the professor and the three researchers were all striving to produce peer-reviewed publications in international journals linked to their use-oriented research contracts with firms, which clearly included some elements of UIBR as well. In essence, therefore, this example of a dynamic research centre showed an interesting combination of PAR allied to some UIBR.

It must be stressed that, in 2005, Case 7 appeared to be one of only two or three of the original 10 use-oriented research groupings which had consolidated itself at a significantly **enhanced level** of research performance compared to 2000. The main factors that enabled its transformation from a small **virtual** unit in 2000 to a larger **new real** centre in 2005 included, firstly, the existence of local support from its own UoT and national support from the NRF. Secondly, there was commitment and perseverance on the part of its core group of three researchers, who had attained their doctorates during this period and then driven forward their own research subgroups. Also crucial was the role of the dynamic leader, Prof. Fluids, who drove forward the transformation into a new centre type, and who commented in his interview of 2005 from another angle: ‘They [all 3] got their PhDs. So it changed from their being pushed to them pushing... They can actually supervise PhDs in their own right...’

Nonetheless, it was also clear that there were potential difficulties, or what might be termed areas of significant **fragility**. Firstly, there was a potential tension between the poles of UIBR and PAR in the Centre. For example, it was clear from the interviews in 2005 that, being based at an ex-technikon and facing research competition from its three neighbouring universities, the strength of the Fluids Centre could not mainly lie in an area of UIBR, although it was positively incorporating some components of this work. Yet there was pressure on the Fluids Centre, given the increasing emphasis on NRF ratings for all academics after 2000 in South Africa – including pressure from national research leaders and the DoE funding subsidy mechanisms, and also from some of the senior research managers within this UoT – to shift the research more towards ‘basic’ problems and associated research publications in international journals, that is, in the direction of UIBR. At the same time there was pressure to conduct research with more orientation towards PAR and perhaps even some routine testing and routine experimentation, because this would provide more industry contract funding and would encourage the Fluids Centre to utilise more effectively its newly expanded, well-equipped laboratory.

There were thus strong pressures from industry causing a potential drift, like that of Professor Commerce in Case 5, towards more applied research, including
components of routine consultancy work. In fact, Prof. Fluids had mentioned, in interviews of both 2000 and 2005, that there had been occasional tensions between his research grouping and the industrial firm of his two engineering colleagues, because the latter also had a well-equipped laboratory in this subfield of work and sometimes questioned him about his taking industry contracts which might be undertaken by their firm.

A difficult yet feasible route to follow, I will argue in Part 3 with respect to UoTs in South Africa more generally, clearly seems to be this: to concentrate on the PAR side of the research spectrum with genuine research (new knowledge) development, as in Case 7 here, incorporating a strong orientation towards context-specific projects requested by industry. But at the same time, some fundamental knowledge components should be retained as well, in other words, always incorporating some UIBR. But this would require good and clear-sighted research leadership within a centre like the Fluids Centre, as well as support from the UoT leadership.

This leads to a second perceived area of fragility: if this professor-director were to depart, the Fluids Centre might experience disruptions (as happened in Case 8 that follows). This also raises questions about how to consolidate such Model A-type centres so that dependence on an individual leader is not so crucial, a concern explored further in Part 3.

Thirdly, while some of the UoTs have, since the late 1990s, become increasingly oriented towards enhancing research and postgraduate studies, in 2005 the interviews with the Fluids Centre continually brought up problems of the ‘research culture’ at the ex-technikons. This weak institutional research culture undoubtedly acted as a brake on some of the research activities of the Fluids Centre.

Fourthly, and perhaps most importantly, the UoTs, like the technikons of the past, face the continual problem of recruiting and retaining high-quality researchers. For example, one of the researchers noted in an interview in 2005:

Somebody [in industry] just called me the other morning and said, you know, they’re looking for a pipeline engineer for R450 000 a year. [They asked] ‘Would you be interested?’ You know, they would [therefore] double my salary [at the level of senior researcher in the Fluids Centre].

Early 2007: Follow-up interview with the Centre director

Before the interview of 2007, the above considerations made me conscious of factors exacerbating the fragility of the Fluids Centre. So it was with some surprise, and also admiration, that I found that the Fluids Centre had not only stabilised, but even expanded a little, including in its research output. Moreover, after seven years of work, Prof. Fluids had finally succeeded in forming a South African academic-professional association in 2006 for those involved in activities in the Centre’s research niche area, along the lines of the national association he had seen in another country a decade before.
In terms of its core structure or internal mode of organisation, the Fluids Centre in 2007 had remained almost exactly as it had been in 2005: in essence comprising the director and subgroups led by senior researchers, supported by a Centre administrative infrastructure. In addition, they were trying to recruit back, as a post-doc, one of the students from abroad who had obtained her PhD in association with the Centre shortly before.

Interestingly, not only had the two senior researcher positions B and C been retained in 2007 without any significant teaching loads having been added to them, but these two senior researchers had themselves greatly developed their own research work. Associate professor (formerly researcher) C, now also assistant director of the Centre, had enhanced the UIBR components of the Centre with her own considerable research output rooted in her physics background; and at the time of the interviews she was overseas on several months of research visits, including an invitation to give lectures to a prestigious group working in this niche area in Europe. Senior researcher B was also abroad for six months at the time, working with an overseas group on his emerging speciality within the Fluids Centre. Clearly, therefore, Prof. Fluids' efforts to obtain from this UoT the two permanent positions of senior research officers were paying handsome dividends in terms of research output for this Centre.

Of interest, too, was that the Fluids Centre, whose current funding cycle with the NRF was ending, had applied for a new cycle of NRF support in 2006, but this time broadening its niche area a little to include the sub-areas of a few other academics in adjoining departments (engineering, applied sciences). In this way, not only would the Fluids Centre enlarge its number of core and affiliated senior researchers – each leading their own subgroups within such an extended network – but it also sought thereby to be called an 'institute', a name change supported by its UoT and submitted to the NRF as part of this new funding application.

Besides the above major components of consolidation, including research funding from the NRF, it was noted in the 2007 interview with Prof. Fluids that industry funding (including a THRIP portion) had grown such that the number of laboratories had increased from two to three. As in a few other case studies, Prof. Fluids preferred his Centre to remain based inside his academic department: 'And we are keeping ourselves very closely associated with [i.e. within] the [name of his engineering department].'

Factors that could undermine the stability of the Centre continued to play a role, however. There were continuing concerns about the research culture of such a UoT, and the merger between the two technikons begun after 2004 which had led to considerable disruptions. Moreover, there was still an ongoing tension between UIBR and PAR, including with respect to the NRF rating system: Prof. Fluids had achieved a renewal of his C1 rating after 2005, but noted in the 2007 interview that he had been told by the NRF: 'We want to see more journal publications.'
Yet, in an illuminating discussion in this same interview, he had inferred that, while unpublished ‘technical reports’ for industrial clients often formed the basis of the Fluid Centre’s PAR work, in fact some of the most valuable research outputs for such clients were in a much more intangible form, like telephone conversations or workshop presentations or even being flown up to Johannesburg ‘for a chat’:

Twice, there’s a company, dredging company [name], they just asked me to come [up north] and have a look at something...for them it’s worth R100 000. They get me in a workshop and they say, ‘Now look at this here, what do you think of this?’ Because I can’t resist it, I say, ‘No, but you’ve done that wrong, you should have done this, this and this...and you know, I sort of say to them, ‘We can investigate this problem,’ but I never hear back from them, so they obviously – whatever they wanted, I told them – and its happened more than once.

Yet later in this interview:

Interviewer: But you see, that’s not part of rating [by the NRF, it doesn’t rate such intangibles, e.g. a slide presentation or a walk around a firm’s plant].

Professor Fluids: No, that doesn’t even come close! [to being considered for rating evaluation]

The tension between UIBR and PAR in many of the 10 use-oriented cases, as well as the problems of our NRF researcher rating system, which heightens the fragility of valuable, high-quality PAR and even UIBR work for clients (industry, government, civil society), will be discussed further in Part 3. But the analysis of Case 7 itself can be concluded at this point with a clear assessment that, at least in 2007, it was an excellent example of consolidation into a vibrant, use-oriented research group along the lines of Model A, a new (real) centre, and moreover at an ex-technikon.

In addition, whatever our research leaders believe about national research rating, South Africa’s industrial leaders continue to invite researchers such as Prof. Fluids to help with our national industrial development and economic growth. In other words, there might be many South African academics who do not see the value of the third industrial revolution and its associated second academic transformation, but the industrial executives of the dredging company that flew Prof. Fluids up north cannot be counted among them!

**Research groupings in transition between Model T and Model C**

This section considers three research groupings, two based at Western Cape UoTs (Cases 8 and 9), and one at a more research-intensive university (Case 10). My argument here is that all three cases were in transition from a situation of a small traditional (virtual) unit (as exemplified by Case 0), to one involving UIBR and PAR, comprising a network of professors and their subgroups, in other words, what I have termed a ‘new virtual centre’, as exemplified by Case 3. Moreover, despite the fact that
all of them defined themselves as a ‘centre’, I argue that it is more fruitful analytically to view them as being located in between the Model T and Model C types of research structure (see Figure 5.4). Thus it is suggested that the research director and network of professors of each of the respective cases to some extent misunderstood the structural type of their grouping – leading to all sorts of problems and complexities in the operation of the grouping.

**Figure 5.4 Research groupings in between Model T and Model C**

*Curiosity-oriented (PBR)*

**MODEL T**  
Traditional (Virtual) Unit  
(exemplified by Case 0)  
Professor researcher-lecturer,  
Postgraduates & a few post-docs,  
Sometimes in a lab,  
Peer-reviewed publications,  
Based in an academic department

**MODEL B**  
New (Real) Unit  
(exemplified by Case 2)  
Use-oriented (UIBR+PAR)

**MODEL C**  
New (Virtual) Centre  
(exemplified by Case 3)  
Professors & subgroups,  
Postgraduates & a few post-docs,  
Sometimes in a lab or labs,  
Peer-reviewed publications and some clients,  
Based in an academic department or faculty/school

**MODEL A**  
New (Real) Centre  
(exemplified by Case 1)

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**Case 8: Professors in a Centre-as-Department – in transition between Model T and Model C**

**Early 1990s origins: Developing a UoT department into a research grouping around the HoD**

As in the case of the Fluids Centre (Case 7), the professor-leader of this UoT research grouping had obtained his master’s and PhD degrees in engineering at a nearby Western Cape university. As he outlined during the 2000 interview, he had always had a ‘passion for research’. In the early 1990s he had taken up the offer of HoD in this UoT’s engineering department, as he put it, in part to gain independence from
his university PhD supervisor-mentor (‘a world leader in my field of research’). He also felt that a UoT could provide a home for directly applied research projects (i.e. PAR) linked strongly to industry (which requested the context-specific projects), which he sought to drive forward.

However, soon after his entry into the UoT, he was shocked to see that nobody was there during the first April teaching break. As he put it in the interview in 2000: ‘All the doors were closed; the secretaries asked me what I was doing here [in the early 1990s].’

One of his goals became to address this lack of an institutional research culture. Fortunately, he gained the support of some very senior administrators in the institution, and he became chair of his faculty research committee after the mid-1990s, when the then-FRD was developing its Technikon Research Development Programme of support. As a result, he sought to build up a critical mass of academics (i.e. researcher-lecturers) in his own department and across the science and engineering faculties to which he was linked.

His strategy, which positioned his department as the fulcrum around which all departmental research activity revolved, comprised the following core components: i) developing industry respect and faith in UoT-based research; ii) encouraging all his lecturing staff to become involved in research around a common departmental research programme, which he coordinated as HoD and also supervised, since all lecturers enrolled in either an MTech or DTech in order to upgrade their qualifications (in 2000, none held a doctorate); iii) expanding significantly the number of master’s and doctoral students in the department (in 2000 over 10 of these theses were supervised by the professor himself), with some of these postgraduates serving as research assistants in the various industry-funded projects of the department.

The nature and structure of the Centre-as-Department grouping in 2000

During the interviews in 2000, it became clear that the essentials of this HoD’s approach to research development comprised what might be termed a ‘within-department’ virtual centre: a cluster or network of all the researcher-lecturers based in a single engineering department. The nature and structure of this Centre-as-Department appeared to be shaped by the following important elements.

The HoD had created an Advisory Board of some 12 members for the department; about two-thirds of the members of this Board had been drawn from leading companies linked to research projects growing within the department. The research leader-HoD had been very active in soliciting financial support from industry, including laboratory equipment, student bursaries and the sponsorship of one research assistant position by a company. Some industry linkages derived from networks with which he had connected while doing his PhD at the neighbouring university. But, interestingly, quite a number of industry connections had emerged, he suggested in the interview, from networks that developed when he (as HoD) helped
to secure in-service company training for his undergraduate students – internships, as required by the UoT National Diploma system. Clearly, therefore, a number of UoT-specific factors were shaping the U–I networks of this Centre-as-Department.

By the time of the 2000 interviews, a departmental research culture was growing around 18 MTech and five DTech enrolments. There were research links, in terms of joint research projects and sometimes co-supervision, with neighbouring university engineering departments, as well as occasional sharing of laboratory work and postgraduate coursework modules between these HEIs. Driving this new culture was the research leader-HoD, who had published a range of articles in international journals, attended numerous international and national conferences, and set up links with some universities overseas; he had, furthermore, been invited onto a parastatal board and an NRF committee and served on a government commission.

Nonetheless, the anchor of this research ‘virtual centre’ was the network of researcher-lecturers within the department. By 2000, this department had grown to five lecturers, three technical officers and one researcher, almost all with industry experience, including one of their own black B Tech students who had returned as a lecturer after a spell in a company. Moreover, under the professor’s leadership, the department had defined its research orientation clearly within what I would view as Stokes’s (1997) category of PAR: it stated in its mission that research ‘projects are chosen such that the output is valuable to industry’ and ‘the emphasis is placed on applied research with established commercial value’. Four research sub-areas had been established, each headed by one of the departmental academics as project leader; departmental technical officers and research assistants gave support to these sub-areas, as did postgraduate thesis students who became linked to a respective sub-area. Most importantly, all four sub-areas fell within an overall research niche programme which the research leader-HoD had established for the department as a whole, with due consideration of different and complementary research niches pursued by similar engineering departments at the two neighbouring universities. The professor put it thus in his interview of 2000:

…[the advantage of] a focused research programme is that you can come up with a lot of in-depth answers to questions…if you spread yourself too thin over a variety of research projects, you actually become a consulting commercial group at the end of the day…

[Moreover] If a department is big enough, members could form groupings each with its own focus – this happens easily at UCT and Stellenbosch where there are a lot of different people with different foci. But our [UoT] department is still too small…at the moment I don’t see any benefit of going this route.

The above points suggest that, at least since the 1990s, there have been no fundamental barriers blocking a dynamic HoD from driving forward innovative research groups within the UoTs.
Nonetheless, at the time of the 2000 interviews, I wondered whether there might not be problems with this approach of, in essence, constructing a whole department as a new virtual research centre. In particular, I was concerned that the following serious problems might arise:46

- Not all academic staff of a department might want to pursue their research within the research niche or programme set out by the HoD. This might be especially true for a department like this one, where it was clear from an overall reading of the interviews and documents of 2000 that ‘its core business remained teaching and training’.47

- Possible role conflict might arise if a professor acted both as HoD and as director of the (virtual) research centre within the department. Again, this could be especially relevant in a situation like this one, where it was clear that this single professor was creating a strong sense of direction and cohesion, giving the lead to a more junior complement of researcher-lecturers. What might occur if such a leader were to depart and a new HoD were to enter?

Soon after 2000, this leader did actually depart, to accept a different senior position outside Cape Town. My second round of interviews in early 2005 sought to investigate some of the consequences of his departure, especially in relation to the grouping or ‘network structure’ which had been constructed by 2000.

Departure of the HoD: Destabilisation of the Centre-as-Department by 2005

I interviewed the ex-HoD in 2005 about his perceptions of what I viewed as the Centre-as-Department, nearly a decade after he had initiated it. Interestingly, at the beginning of this interview he confirmed my analytical assessment of the structure he had previously tried to build:

Interviewer: And you were what I called in my report, a ‘department-cum-research unit’…basically, a department acting as a unit [research grouping] as well, is that right?48

Ex-HoD: Precisely, precisely…all the academic staff participated in the unit…Then we had, obviously, a large group of students, the master’s and doctoral students, and then we had research officers, technical officers, those were sponsored by industry onto the project.

He went on to outline some of the problems which he felt had emerged after his departure. The department had advertised twice for a new head to lead both the research grouping and the teaching, but was only able to obtain someone close to retirement, seconded from another department being dissolved at this UoT. In his view, without dynamic leadership there was always a real danger that the emerging departmental research culture and activities would become fragmented:

One of my tasks was to create a critical mass [of researchers] and to develop those people. When I left [soon after 2000], none of those [five academic staff] were really yet at the level to just take over my shoes and run the unit…they were all registered for a doctorate, none of them actually had
The university in development

a doctorate... So, the team spirit and the actual integration of people here, at this level, started to be grave... So everybody was trying to do their own thing... and you've got friction, and that was the reason [in his view] why this thing just collapsed in three years... A part of that [his role as head of a research unit] is in fact ensuring there's a massive good team spirit, and I think if that isn't there, then you can kiss your unit goodbye.

It seemed, therefore, that 'this thing' had been collapsing by 2005 although, interestingly, the subsequent visit in early 2007 (see below) suggested something else. In addition to the problem of some fragmentation after the HoD's departure, there were also problems clearly linked to declining finances from industry. As the ex-HoD put it in the interview of 2005:

And what has happened is that the industry support has also pulled out [quite substantially]. Because ultimately, you can say what you want, but industry is not necessarily supporting a unit – they are supporting individuals in that unit. And I think if they don't see those individuals there anymore, they won't pull it out immediately, but they're going to ask specific questions; and if they don't get the response that they want to hear, they're pulling it out...

Another interview with one of the younger departmental academics in 2005 confirmed that most of his funding now came from the NRF, although he noted that two other academics had maintained links with industry funding. Nonetheless, all was not doom and gloom: while working on his doctorate, he had continued work in his own small research group with two or three master's students, two of whom had been the first at this institution to obtain NRF (special names) Scholarships. Interestingly, too, instead of building links within this department, he had begun developing laboratory links with allied academics in the adjacent Faculty of Science, as well as linkages with one or two academic staff working in his subfield of research at neighbouring universities. The ex-HoD had continued for some years as both his DTech supervisor and as supervisor for most other departmental members' doctorates. However, completing a doctorate within an environment that was historically more geared towards teaching was not easy, as this young researcher-lecturer explained in 2005:

It's very difficult, like I said, to be a researcher and a lecturer at the same time. The load is just next to impossible sometimes...[per week] we lecture about 18 periods, which is about fifteen hours...then you still have your [teaching laboratory] practicals obviously, outside of that...[and later] what we have tried for the past three years is taking on some lecturing load from somebody else so that that person can go on sabbatical [historically there had been no paid sabbatical leave at the technikon; his colleagues had funded their leave partly from money in their own research accounts, he explained].

Unexpectedly, though, it became clear from his interview that some stability had nonetheless been achieved by 2005: while the Centre-as-Department might have
fragmented, in no way could you ‘kiss goodbye’ to the department itself. Importantly, even in 2000, most of the five lecturing staff held tenured academic positions (at mostly lecturer or senior lecturer levels), and it emerged that the same five were still there in 2005, all now with tenure and trying also to complete their doctorates. Only one new junior lecturer and one new technician had joined (when one had left), and the other two technical staff had remained – illustrating the stability of an academic department rooted in norms and practices of the first academic transformation of teaching-cum-research by a group of tenured academics.

Thus, for this Centre-as-Department, the new snapshot generated by my interviews of 2005 suggested that, although the Centre side had faded, the Department side, including some components of research, was definitely alive. At the same time as I was finding out early in 2005 that Case 7 (the Fluids Centre), in an adjoining engineering department of this same UoT, was beginning to consolidate itself and flower as a ‘new real centre’, the young researcher-lecturer interviewee cited earlier quite spontaneously made the following comments about this same Fluids Centre (with which he was familiar):

Interviewer: If I gave you a sort of golden wish, I mean, what would be the best thing to consolidate this [his own research work]?…would you try and consolidate, would you go for the department and research structure where the research is inside [as Centre-as-Department], or would you suggest for a [research] unit alongside [the department]?

Young researcher-lecturer: I would suggest like they have at the [neighbouring department name] where there, Professor [name of Prof. Fluids] has his research area separate to the department.49 I would, I actually like that. I think it’s more productive…[but] I’m sort of split because here [in his own department] you don’t lose touch, you’re in touch with academics and with research and undergraduate students and postgrad students. And I think there’s a certain degree of satisfaction that goes along with that, because you can feed back some of the research into your undergraduates. If you remove it then you’re slightly more distant from that, but in terms of being productive, in terms of doing the research and getting the articles out and getting the subsidy for it – I think it’s probably more efficient that way [like the Fluids Centre]…I think [however] he [Prof. Fluids] could justify that post [for a tenured researcher without teaching duties within the Fluids Centre] because they’ve got a lot of industrial funds.

Moreover, when I undertook a final interview with a relatively older researcher-lecturer in this department in early 2007, I found his research growing, in some ways more productively than in either 2000 or 2005 – by working with his own small research group in his little laboratory, within the department. Furthermore, he mentioned that the research of the above younger researcher-lecturer, interviewed in 2005, was also fairly stable in his small, separate group.
Early 2007: Interview with another researcher-lecturer

A final interview in early 2007 with this relatively older researcher-lecturer within the department suggested that – despite the expectation that the research side of this department might decline significantly – if research was driven by a resourceful academic within a department, this research work might actually grow productively around the academic’s own small ‘traditional’ group or lab, even though the wider Centre-as-Department grouping might dissolve.

This academic suggested during the 2007 interview that, after the previous HoD had left in 2001, there had been some confusion around research work in the department. For a time the department had formally held onto the idea of the original, single research programme or niche which in 2000 had provided the umbrella for all their research work; but then a number of academics in the department began to develop their own research directions, usually assisted in their work by a few MTech students. However, master’s student enrolments had declined in the department as a whole, from nearly 20 students in 2000 to fewer than 10 in 2007. The merger of the two technikons begun in 2005 had also resulted initially in some general confusion across both campuses. These factors had not created a framework conducive to flourishing research, he argued.

Nonetheless, around 2004 he had come together with another academic in his department to focus jointly on a special experimental process which they felt was in considerable demand by some companies with respect to PAR, allied to some routine consultancy work. For this, they began to obtain funding mainly from industrial company sources and THRIP, which enabled them not only to contract one or two MTech students as well as an occasional administrator to work in their small, informal research group, but also to pay for equipment to construct a small but effective laboratory within the department, in which all their projects could be undertaken. By 2007, they had developed collegial links with allied departments at the two neighbouring universities, involving also supervision for the completion of their own respective doctorates.

This researcher-lecturer and his academic colleague both had full teaching loads within their department. Yet it was noted in the interview that each year he was managing to produce one or two journal articles, linked to contract research reports for the funding companies, which were an important output as well. In addition, he had recently also been invited onto the editorial board of an international journal in this subfield, so, ‘The radar is picking up, the technical international radar is picking me up!’

So in fact this researcher-lecturer, far from ‘kissing goodbye’ to his research, had effectively fallen back into a structure not unlike that of the traditional (virtual) unit of Professor Science (Case 0): himself with a few postgraduates, linked here to one other academic colleague in the department. This small virtual unit, or ‘my lab’, as this researcher-lecturer called it, was doing well – actually much better than had been expected when the interview was set up in early 2007.
Admittedly, his colleague did mention during my tour of their lab that the departure of the HoD after 2000 had caused an irreparable loss: the decline of an overall research programme and direction for the academics within the department as a whole. Nonetheless, it was clear that the small informal research unit of these two academic colleagues and the now separate small research groups around a few other researcher-lecturers in this department were in no way in serious disarray.

This case forced me to look more closely, once again, at the pervasive strength and sustainability of a ‘little science’ research grouping around an individual professor like Prof. Science (Case 0) or Prof. Genes (Case 2), particularly because the original 2000 Centre-as-Department of Case 8 was no longer functioning in 2007, not even as a virtual centre. Clearly, an individual professor within a department, as PI-cum-lecturer, has stability, not least because such an academic has tenure. In fact, it emerged that every single academic (and technical) staff member of this department who had been listed during the 2005 interviews, was still there in the same job (and usually conducting one or two research projects) in 2007 – thus highlighting the tenacity of first academic transformation processes based on practices of tenure and historical discipline–department structures.

A tenured academic does thus provide a building block around which any research group (real or virtual) can be constructed or reconstructed. Such a department-based PI of a small, use-oriented research group seems to be a more resilient structure than the kind of centre that often arises in our universities, only to dissolve some years later. Perhaps it was the following concluding remarks made by this researcher-lecturer towards the end of my 2007 interview which ensured that the phenomenon of the robustness of the little-science PI ‘molecule’ within South African (and international) universities would become an unavoidable central issue for my research project:

Interviewer: But overall, would you say as much research is being done now [in the department] as under [name of HoD in 2000]?

Researcher-lecturer: Probably a little bit more, even. But, it’s more diverse [across separate groups].

Interviewer: …So, would you say in terms of your own work, you’re doing more research now than you did under [name of HoD in 2000]?

Researcher-lecturer: Oh ja.

Interviewer: And for [name of departmental academic colleague who joined his group] as well?

Researcher-lecturer: Yes. Well you see, the beauty about it is we’ve worked out how the synergy thing works [as two linked colleagues], we’re able to achieve more, and having [name of their MTech assistant, on a two-year contract just signed] there, working full-time on the [name of lab project], is great.
Clearly, at least for these two academic colleagues within the same department, this small research grouping of two researcher-lecturers and one postgraduate assistant was in certain ways working better for them in 2007 than a Centre-as-Department had done in 2000. Part 3 will explore this issue further as it arises across the case studies, in terms of problems of consolidation of Model A centre-type structures in South African universities, especially within a context of: i) serious research underfunding at our HEIs; ii) difficulties of securing research directors for the centres; and iii) the absence of a promising and secure career track for senior researchers within the new real research centres.

Case 9: Professors in a Centre-in-a-Faculty – in transition between Model T and Model C

A UoT with champions for research centres and units after the mid-1990s

Case 9 also involves a faculty of engineering at a UoT where, until the mid-1990s, there was a relatively weak research culture. At the time of the 2000 interviews, this case appeared to be one of the most innovative in terms of a vision of an engineering-applied science research centre, comprising a series of research units or groups to be built across departments within one faculty, even across faculties, and forming in effect a network of professor-researchers spread across science–engineering. In terms of this vision, the Faculty of Engineering would provide the main ‘container’ for the research groupings within such a newly conceived centre. Interestingly, these attempts took place in the late 1990s at a UoT where, in comparison with the universities of the region, there had been a very limited research culture because undergraduate teaching had absorbed over 95 per cent of the energy of its academics during the previous two decades. Perhaps as interesting, and as unexpected, is the fact that one source of this conception of a research centre was the American university of MIT itself.

A force shaping this innovation was the NRF, which in the late 1990s pushed forward with a Technikon Research Development Programme whereby, with NRF finance and advice, there was an attempt to kick-start new research in each UoT via ‘research activity areas’ of focus around specific research units or groupings. Another force was this particular Faculty of Engineering, which developed its own strategic five-year plan for research linked to NRF support. Here an important factor as champion for a ‘MIT vision’ was the faculty dean.

As in Cases 7 and 8, each of which had a dynamic driver of research, this ‘dean-champion’ of research also had a university background. He had distinguished himself in undergraduate and master’s engineering degrees at a neighbouring university, followed by a scholarship abroad to attain a broader qualification outside of engineering. He committed himself to returning to South Africa thereafter, as he outlined in the interview of 2000: ‘I felt research wasn’t all that relevant at the time [around 1980] to South Africa’s development and perhaps the work at the technikon [as head of an engineering department] would be more relevant.’
For two decades he had served at this UoT, mainly as a teacher and administrator, ‘though I still yearn to be back in the laboratories doing research,’ he commented in 2000. After the mid-1990s, in the new South Africa, he and a few others in the faculty, with NRF support, set about conceptualising and constructing a set of research groupings linked to niches of perceived strength. The core of this faculty strategy was the development of what they called a research centre, for what was termed in their documentation ‘research in applied technology’, which in essence involved PAR with respect to Stokes’s (1997) categories.

What exactly was this ‘vision’ of the centre? Effectively it was an attempt to develop three core activity areas around three laboratories respectively, within the Faculty of Engineering, all oriented towards ‘design for manufacture’. It was planned, moreover, that this centre would give rise to a spin-off company to facilitate technology transfer to industry. In addition, departments in engineering were encouraged to initiate their own research groups linked to this development, each to be driven by a senior academic; the science faculty, too, began to establish two or three such units in its departments, sometimes linked to this new centre. Another goal was the development of a cohort of MTech and some DTech students as research assistants within each activity area, with bursaries funded primarily by the NRF. In this way, a new and vibrant structure of applied research would be built, constructed around a network of research groupings oriented towards technology for industry, in other words, not unlike the idea of an NCE discussed in Chapter 3 in relation to Canada and some other countries.

Some problems evident in 2000

The envisioned structure of this centre, in terms of my classification scheme, fitted the type of a Model C virtual centre, comprising a network of professors mainly within one faculty, each pursuing their own research directions but loosely under the ‘direction’ of a head of centre – yielding my term new (virtual) Centre-in-a-Faculty for this case.

Yet, in 2000, this centre structure was still only potential: a crucial ingredient for its realisation was to obtain and retain research ‘drivers’ to lead the various research subgroups and the centre itself. The dean of engineering at the time was aware of this, for at the end of the 2000 interview he was asked:

   Interviewer: If you could draw up a wish list, what would you put on it?
   Dean: For me, being able to get qualified, competent and enthusiastic staff with initiative and vision is what I would like. I have found from past experience that if you want anything to happen you have to have champions. If all my research projects could have good people it would be great…We have tried to employ staff with good research and with at least a PhD.

This statement clearly encapsulates a vision of senior researchers, or what I have termed for some other cases ‘associate professor-researchers’, leading each subgroup.
This layer, it has been argued, is essential for establishing a viable and sustainable research centre along the lines of Model A, but it is also essential for a Model C-type new virtual centre.

In 2000, it was not possible to explore in great depth all the problems facing this centre. Nonetheless, from the interviews conducted with this dean and two senior researchers involved in this grouping at the time, it was clear that the recruitment and retention of research drivers was one of the central problems. For example, the dean decided that one way of supplementing his faculty's senior researcher-professors was to recruit from other countries, including Europe and Asia. He did secure one person in this way, but another who agreed to head an activity area was lost because the Department of Home Affairs took over nine months to process a work permit (apparently, they had lost three potential overseas researchers as a result of such delays). Not only were there immigration problems, but there were also emigration ones with respect to South African researchers. As the dean argued in 2000:

A lot of them are finding jobs at universities abroad, especially in the high demand areas of telecommunications, information technology and engineering...The government can relax this whole work permit issue...they [foreigners with research expertise] are not taking jobs from any South African. There are not enough South Africans who want to come here [to this UoT].

The dean had also sought to make attractive the new faculty senior researcher positions which he had established, by using money to bring in part-time staff to relieve the ‘research activity leaders’ of much of their lecture loads. Another strategy was to attract post-docs from the two research-intensive universities in the Western Cape, and the faculty was trying to ‘grow its own timber’ too, but the dean commented:

If you look at our situation at the moment, we have difficulty retaining our own good students. We are trying to fill junior lecture posts to retain some of the good students [with each pursuing a D'Tech, on a reduced teaching load] but the best still don’t stay on. They are the high-flyers and earn big bucks in industry. [Yet the irony is] We can get good students from overseas. We have had two very good students from [specifies a country from Asia]. The one is doing his PhD at UCT. He did his masters with us. We had one student doing a D'Tech with us. The problem with foreign students is that the NRF won’t give them funds.

This innovative dean was therefore doing all he could to avoid the staffing problems which continued to obstruct the development of his new research centre and its units.

Perhaps most serious of all was the fact that the director of the centre, after he had noted (in his own interview) with pride that his developing centre in 2000 contained 14 of the 25 full-time postgraduates registered at the UoT, added that after driving
this research project for five years, he was now leaving. A major reason for his departure, it seemed, was money, as the dean of engineering stated in his interview of 2000:

What happens is that an entire research area can collapse if we don’t have a project leader…I relied heavily on him [the director of the centre] to promote research and take us forward in the faculty. He was [also] the activity leader for manufacturing and then at the end of last year he handed in his resignation…with his current salary he is struggling to make ends meet. He can earn four or five times as much in industry.

The departing centre director, in his interview, mentioned other problems as well, such as a lack of support for the research initiatives by some of the senior management: ‘…[they still feel] the technikon is there to produce undergraduates not postgraduates.’

The director further stressed how difficult it was to obtain and retain D’Tech students, whom he viewed as vital researchers for his labs:

My philosophy is to take a PhD student and pay them properly, i.e. R60 000 scholarship per annum. That is seen as a lot of money and a wastage of money because these students leave after a while…[this] is about double what they are getting at this moment in time [from the NRF], then you will spend over the four years, R240 000 per student, maybe R1 million for four students.53 If one out of the four stays on, he can soon [as a post-doc] bring in that kind of money [in research contracts]. In the meantime, you have built up research publications. You have attracted undergraduate students into the programme. You have created an image out there in terms of reading papers at conferences. The rewards are tremendous but they [many of the other senior administrators and academics at his technikon] don’t see it that way. Those are areas they should look at…Otherwise you won’t attract these guys into research.

Moreover, it seemed that some of the departmental academic staff appointed in the past as technikon teachers without a master’s qualification felt threatened by the new research thrusts – an important reason, the director argued, why research centres like his should be located outside of existing departments. It was suggested, too, in some interviews, both at this UoT and at a historically black university in the Western Cape, that racism and elitism (perceived and real) at neighbouring universities penetrated the research enterprise much more deeply than was often assumed, making research cooperation difficult across institutions.

Clearly, there was a set of intersecting problems affecting what seemed to be well-conceived new structures for this emerging Centre-in-a-Faculty. But a crucial lesson from this case in 2000 appeared to be that, however good the vision, this had to be followed by recruitment and retention of senior-level researchers in particular. As the main driver of this project, the centre director who was leaving put it in 2000:
There is a big misconception that research can be driven by managers who are not technically clued up with the actual nature of the research. That is a huge misconception...When it comes to driving research you need the right people that know what type of research is going to succeed out there, what type of research industry will buy...people that understand research. That has been a big problem at this institution...

Early 2005: Interview with the former dean about what had emerged as an unstable centre

My interview in early 2005 was conducted with the previous dean, who explained that he had left the Faculty of Engineering soon after 2000 to take up a higher-level position within his institution. Two major insights were gleaned from this interview with respect to the centre. The first of these emerged unexpectedly and quite unprompted, midway through the interview:

Interviewer: [in the international literature about research in 2005] there's a clear concept of these Centres of Excellence. Now, your research unit, of all my 11, seems to have actually the strongest vision...Where did you get it [the vision], am I right, were you picking up international trends?

Ex-dean (of engineering): Well, I must say, a lot of my own thinking has been influenced by my experience at MIT...

Interviewer: Oh? So you spent time at MIT?

Ex-dean: Ja, I studied there...

And then more information emerged about the impact that MIT had had on his vision of this research centre:

Interviewer: So, did the MIT have some of the engineering [research] groups running like this [within his centre]?

Ex-dean: Oh, they had many, many cross-disciplinary types of laboratories, programmes, just amazing – the whole thing.

Interviewer: The things were called 'centres'?

Ex-dean: Well, some were the centres, some were laboratories, some were units, you know, so there were different designations...[there were strong] links with the industry; interdisciplinary like you can't imagine, and also involving students at all levels...

Interviewer: In their units and centres, were some of them full-time researchers?

Ex-dean: Yes. Oh, yes, quite a number.

Interviewer: So they weren't all just professor lecturers?
Ex-dean: No. They had full-time researchers there as well. So that was the vision, I must say, and then we tried…

Interviewer: Okay, now it makes sense.

Ex-dean: We tried, I mean, I tried.

In other words, according to the former dean, the MIT model experienced first-hand some years earlier had been quite purposefully applied to his new engineering research centre, which comprised research groupings seeking technology transfer to industry in the Western Cape and elsewhere in South Africa. It thus began to seem as if this would be a rerun of the situation of the university-based Space (Virtual) Centre (Case 3), where MIT and Stanford had had a significant influence on the engineering professors in their very successful Space project. But whereas the Space Centre had, by 2005, blossomed into a strong departmental laboratory with diverse research groups, the opposite was revealed for this UoT-based Centre-in-a-Faculty, which had experienced a downturn.

This downward trend was the second major insight gleaned from my interview of early 2005 with the ex-dean. It emerged that the Centre-in-a-Faculty now hardly existed as a structure any more. It seemed that retaining another director of the centre at this relatively research-underdeveloped UoT after the departure of its first director in 2000 had proven very difficult. A new director was thus recruited from a neighbouring university, and was designated ‘coordinator’ of all research in the Faculty of Engineering; but he departed again after a short while to undertake private engineering work outside of HEIs – highlighting the problem of obtaining and retaining a director of Model A (and also Model C) type research centres at many South African universities. With the dean also moving into a higher position in the institution, leadership waned somewhat. During the 2005 interview, the ex-dean suggested that, although two of the ‘research activity areas’ within the engineering department were still ongoing, under the respective leadership of two of the original professors of 2000, most other research groupings in engineering remained underdeveloped.

At this UoT, therefore, it seemed by early 2005 that a set of negative factors had impacted on this case: the historically weak research culture at the UoT, the low levels of research funding nationally, the fragmented research organisation across the Faculty of Engineering and, not least, the lack of success in recruiting from without and/or growing from within the faculty some innovative senior academics as research drivers. In terms of the latter, it is very important to stress that the new virtual centre of engineering professors in the Space (Virtual) Centre grouping (Case 3) at a neighbouring university in comparison comprised a network within a single (engineering) department. Not only did these university professors obtain various financial and other forms of assistance from their own department, but they could also recruit other tenured academics to their labs from within the same department. In contrast, this Centre-in-a-Faculty was spread thinly across a ‘faculty as container’ – which, it is clear, provided less coherence and support than what
I have referred to as a core first academic transformation historical structure, the discipline-department. This issue will be explored further in Part 3.

Given the negative factors noted above, which had resulted in a much weaker Centre-in-a-Faculty type structure than had been envisaged in the original MIT-derived ‘vision’, it was expected at the time of the follow-up 2007 visit that research activity might have declined further. However, I was surprised to find that this was not entirely the case, although some of the resilience evident at this point derived from intra-departmental structures and not from the faculty.

Early 2007: A further interview with one of the research drivers of 2000

Early in 2007 I again interviewed one of the professors who had headed one of the engineering laboratories of the Centre-in-a-Faculty in 2000. Unexpectedly, the research of this professor (called here Prof. F) was continuing – almost alone – with his small ‘project’ (his term), but nonetheless with slightly more research output than in 2000.

Essentially, it seemed that, after the departure of the previous two directors of the Centre-in-a-Faculty, Prof. F had continued and even retreated into his own department with his own research project. Now in 2007 he was what was termed a Niche Area Leader – in this case a co-leader of a group of three academics in his department who all received NRF funding for an NRF-defined niche area. Interestingly, the other co-leader had been his own DTech student in 2000 who, after completing his doctorate, had become a senior lecturer in the same department and worked alongside his previous mentor-professor within this area. This was clearly a case of successfully ‘growing their own timber’, which had been a goal of the dean of 2000. It was also interesting that, while their niche area was loosely linked to one other academic in an adjacent engineering department of the faculty, the core group was in fact rooted in a single department, with each of the three academics of this department effectively ‘doing their own project’, as Prof. F put it. Importantly, too, a fourth professor of his department, who had also headed his own lab as part of the original centre, was still running his lab with a few of his own DTech students in 2007 – but separately from the niche area network of Prof. F and his two departmental colleagues.

The original Centre-in-a-Faculty, with its networks of labs and units envisaged by the dean in 2000, was no longer really in existence by 2007 (although the name was still used in the faculty). As Prof. F put it at one point in the interview of 2007, ‘[name of Centre-in-a-Faculty] was really never more than an idea’. Instead, by early 2007 Prof. F had consolidated his research work around his own research project – almost a one-person unit, but loosely linked via an NRF-funded niche area to his two other colleagues in the department. In essence, the Centre-in-a-Faculty (with a designated full-time director) had thus not even come close to attaining the form of a new (real) centre along the lines of Model A (the original long-term vision), or even a more loosely structured Model C network type. Rather, what remained was, at best, a small
cluster of a few academics in one department, all undertaking their own projects but loosely linked in terms of NRF niche area funding.

Interestingly, too, by 2007 it seemed that Prof. F had shifted more in the direction of UIBR. On the one hand, his industry funding had declined, including the THRIP funding of 2000; moreover, he suggested that in their Faculty of Engineering in 2007, ‘very little is happening outside of NRF funding’. He was pointing here to a lack of expansion of use-oriented engineering research via ‘technology for industry’, as envisaged by the dean. He was also indirectly referring to the vision of a spin-off company linked to their UoT to market the research outputs of the new centre, which had not materialised either. On the other hand, Prof. F mentioned in 2007 that his own departmental funding for their research laboratories and equipment was important – highlighting again the role of having a ‘departmental base’ for his research. And he himself had received an NRF rating as a researcher after 2000, and was pursuing research publications via a more fundamental orientation around computational-applied research, with less focus on the original PAR projects.

In addition, during the interview Prof. F showed documents of his research links with a group abroad, though there were fewer links with researchers at neighbouring universities. He had increased his supervision of DTechs, but lamented that most were from other African countries and countries like China (where, it seemed, there was intense competition to secure a place as a doctoral engineering student), because ‘our own BTech and MTech graduates are snapped up by industry’. He still had a relatively low undergraduate teaching load (following the original system for encouraging research implemented by the dean in the late 1990s when he had been recruited), but by 2007 he had become significantly involved in courses at MTech level. Thus his own research work, and supervision work at master’s/doctoral level, had expanded somewhat.

In summary, in 2007 compared to 2000, the Centre-in-a-Faculty had faded from the core of this Faculty of Engineering, although smaller research projects including that of Prof. F had continued on the periphery. Prof. F’s research was now supported directly by relatively small amounts of NRF funding and indirectly by departmental funding (which covered equipment and his own salary as a tenured staff member). Once again, the resilience of the nineteenth-century first academic transformation structure was evident, even at this ex-technikon with its historically weak research culture.

Case 10: Professors in a Centre-as-Agglomeration – in transition between Model T and Model C

Origins: From unit to centre in the 1980s, led by a research-director innovator

In the early 1980s the research grouping that is the focus of Case 10 was recognised by its university as a formal research ‘unit’, led by an HoD in one of the engineering departments. This departmental head-cum-unit-director had returned to South Africa after spending a decade abroad as an internationally renowned scholar with
prestigious publications in his subfield of research, to take up a chair of engineering in the 1970s at this research-intensive university. His focus was on the fundamental side of engineering research – I would argue, essentially UIBR – in a faculty with a historical focus on the professional training of students for the engineering profession. His strategy, rooted in a decade of post-PhD experience at a leading overseas university of engineering research, was to stimulate research by growing a research cluster or agglomeration of academics in the engineering faculty, linked also to a few academics in the Faculty of Science. In essence, this network or ‘agglomeration’ mode sought to bring together a set of professors within a common research grouping: from the 1980s, this comprised usually more than 10 academics, each one (or two) leading their own research subgroup with master’s/doctoral students and occasional post-docs, but all under the umbrella of a common research theme (in this case, combining computational analysis and engineering–science research).

From early on, the university research committee contributed some core funding to the grouping of Case 10, which was formally designated as a research ‘unit’, and so did the FRD, particularly from the mid-1980s. Moreover, because of the extent and quality of its research work by the late 1980s, the FRD upgraded the unit to the status of a centre, and it became known as one of the leading FRD centres in the 1990s. Most important for its growth, however, was the role of industry: throughout the 1980s–90s significant funding for its research work, and bursaries for postgraduates undertaking their master’s and PhD theses within its various subgroups, was received from a range of industrial companies. As one professor of the Centre-as-Agglomeration commented in his interview later in 2007, ‘[name of director of the centre] had an excellent reputation with industry, through the work of our centre’.

Of importance, too, was the deliberate strategy of the centre’s director to link this agglomeration of academics, whose research was initially affiliated to the unit and from the late 1980s to the centre, to a common master’s programme (coursework and minor dissertation) for their postgraduates. In an interesting conference paper about his philosophy on postgraduate training via academic staff-led research groups, written in the late 1990s, the director stated:

The lessons I learnt at [name of the overseas university where he had worked] formed the basis of what I set out to achieve in my research activities at [name of this Cape-based university]. They had to be adapted to South African conditions and realities, but they served well as a guideline for a productive group. What I propose to do is to spell out [in this short paper] what have been my basic principles for developing a successful research group...[then elaborates a number of principles, including:] research and training of postgraduate students at master’s and doctoral level are integrally linked; research projects are not pursued for their own sake, but as part of a postgraduate programme...[and] it is fundamentally important that the supervisor has a direct interest in the project in which her/his students are engaged. The outputs should be shared work, with joint publications...successful postgraduate training
takes place most effectively when students are part of a group working on similar problems...[such that] a significant amount of learning takes place in these [group] interactions...[and] postgraduate survey courses are an essential component of a postgraduate programme...survey courses which give the students a broad appreciation of the discipline, an appreciation they would not gain from work on their thesis..."

Later he added a principle of 'core competency':

What works dramatically well as a means of binding students together as a group is a core competency that all students in the group develop and share. In my own case, the core competency was [name of computer analytical tool], which is a computer procedure for analysing [name of their research niche]. It has the added advantage of being a marketable skill, so that students who mastered it could also build careers on it. The core competency contributed to each student's thesis...

This core competency thus provided a focus for the training of students via their thesis work, within a respective subgroup led by a different academic affiliated to the agglomeration. This and other competencies (e.g. group work, confidence and pride in one's research outputs) provided the graduates of the Centre-as-Agglomeration with marketable skills in industry thereafter. Essentially, too, the various subgroups provided an innovative, interactive environment within which the aim of growing research within the Faculty of Engineering could be realised – in effect, a wonderful framework for high-quality training of postgraduates around their thesis work.

An interesting question is whether this organisational mode – a loose agglomeration of professors – succeeded more in the training of students than in the development of a common and collective mission-oriented research programme for industry. A further question is whether a shared computer competency, combined with research around what was in fact a very broad area of engineering–science research, was sufficient to hold such a cluster of professors together as a viable research centre (as it called itself). Was it of concern to industry that such a grouping was a loose agglomeration without (in practice) a clear research mission? These questions will be pursued further when considering the ways in which the centre had developed by 2005, and then by 2007. But first the narrative of this case up to the end of 2000 needs to be completed.

The situation in 2000: An agglomeration of professors within Case 10

In relation to the framework of UIBR and PAR established in Part 1, the mission of this centre as outlined on its website in 2000 (with the same wording still in use in 2007), might be summarised as follows: i) UIBR at a level of international excellence, linked to general, global engineering problems of industrialised countries; ii) UIBR and PAR of particular relevance to South African industrial development; and iii) development of postgraduate studies and training in this interdisciplinary subfield of computational analysis combined with engineering–science research.
The mission thus embodied three aims. However, there were clearly potential tensions here, if different academics involved in this research grouping placed relatively more or less stress on any of these aims. This was well captured in the interview in 2000 with the new director, a long-standing member of the centre who had been co-director for some years before the departure of the previous leader shortly before. The new director put it thus, asserting his own stress on having a strong basic science component in all their use-oriented work:

If you talk to different members [academics] of [name of their centre] you’ll get a range of different views, mine is not a unique view by any means. But, I have a quite uncompromising approach to this sort of thing, you know, it is only by ensuring that at all times we are engaged in research work that will find its way into the international peer review literature, that we will be able to maintain our credibility…in any case that’s how I do research. But sometimes, often in fact, we write research reports that are for the benefit of industry and that don’t appear in journal literature, or sometimes we write reports that find their way into conference proceedings, it’s an important way of communicating one’s findings and so on, but the only test really is the peer review literature…if we didn’t do that [publications in international journals], then we would simply become a research centre with a very local, highly South African focus…

However, at least one other academic within this Centre-as-Agglomeration, interviewed in 2000, exhibited a more PAR orientation in much of his published and contract work. An examination of the centre’s output in the 1980s and the 1990s, too, clearly showed an enormous number of technical reports produced for a range of industries and interested groups (by 1998 the listing of these technical reports had reached no. 296); yet there was also, perhaps even more dominantly, a wide range of quality publications of a peer-reviewed nature (by 1995, publications of this sort had reached no. 271).

In terms of the internal structure of this centre, the idea of an agglomeration was actually first derived from a comment during the 2000 interviews by an engineering deputy dean, who undertook much of his research under the umbrella of the named centre: ‘You’ve got to understand that [name of centre] is not an autonomous research unit. It’s an agglomeration of a group of academic staff members who work in a similar field.’

Further insight into the links between ways of funding this agglomeration and the internal functioning of the centre was derived from the interview in 2000 with the new director, who commented at one point that they all met a few times a year as a group of academics, and: ‘It [the centre] was a voluntary association, it still is, there is no constitution, it’s simply an agreement by a group of people to function in this particular way; this informality extended to the way in which we organised our funding.’

He then described how funds coming in from industry, the FRD, the university research committee, etc. were pooled to cover administration costs (e.g. a part-time
secretary was employed) and bursaries of postgraduate students, and to purchase equipment, including shared, highly valued computer software packages, which most (including students) utilised. But, crucially I would argue, he explained that each academic obtained much of his own funding and maintained his own research fund account (from which a considerable amount of the pooled money was also derived), which was self-administered for his own research and also for what they called contract work. Quite a significant amount of the latter was in fact being undertaken by a range of academics in this faculty, linked to their own funding accounts, with such ‘contracts’ viewed as follows by the new director:

If I can come back to your question about basic and applied research, I almost prefer not to make that distinction. There is a lot of applied research that contains original results, it is publishable, you see, in the literature. The kind of distinction that I would make is between research, whether it’s pure or applied, on the one hand and development work, in the sense of R&D or research and development, where development work would be very industrially focused work, you know, get a research contract, a job that has to be done, we do the job, there’s nothing particularly original about it…

Importantly, both the previous director and this new director placed enormous stress on the UIBR side of the research spectrum. Right up to 2007 (see below), Case 10 thus managed to avoid the drift into substantial ‘routine consultancy’ work which was observed within at least one case study earlier. Nonetheless, even in 2000, other problems were observed, which were commented on directly in the interviews.

One problem noted by both the new director and the deputy dean during the first phase of interviews was the fact that quite a few of their postgraduates had later gone overseas (e.g. to work for a company which provided some of the core computer software). There was thus a serious haemorrhaging of the sophisticated expertise provided by this research centre. Moreover, as the new director said in 2000, after his nearly two decades of experience within the centre:

The idea has always been to maintain a very healthy postgraduate programme, with the intention that many of those students would go into industry, but the intention was also that many of those students would take up academic positions. [But] to give you an example, I think without any exceptions, every one of the foreign students I had [mentioned in interview, some came from Germany, some from USA, etc.] is in an academic position somewhere [back in their home country]. None of my South African students are in an academic position.

Thus, like many of the other nine use-oriented research groupings investigated, Case 10 had produced hardly any graduates who later entered the terrain of academia in South Africa. This reflects one of the deepest crises at South African universities: how to reproduce the next generation of academics in our university departments and research units or centres. This question is so serious, particularly given the statistics
on white male academics who will retire over the next 15 years (see Introduction to Part 2), that it will require revisiting in the cross-case study analysis of Part 3.

Of similar concern was the problem, already encountered in many of the case studies, of not offering a long-term future in our research centres to mid-career senior researchers. This centre had drawn together a solid network/layer of tenured, full-time academics (comprising its agglomeration of senior researcher-lecturers); yet for two decades since 1980, it had not managed to construct even a medium-term future for anyone not holding a lectureship position. In 2000, we deliberately sought to interview a researcher who had left because there was no ‘permanent home’ for him within Case 10 as a researcher. This interview showed that, after obtaining his master’s degree in the centre (then a unit) in the early 1980s, he had spent some years working and obtaining a doctorate overseas, returning to the new South Africa after 1990 with the hope of pursuing a research career in this centre. As he put it in the interview in 2000:

> There were changes happening here now [after 1990, with the unbanning of the ANC, etc.], so I thought well it might be a good opportunity to come back, and there was, as I said, a position was available…[and] it [the centre] became recognised as one of these Centres of Excellence…it had quite a few [relatively] permanent researcher officers, which obviously wasn’t there when I had left, in ‘82…they [FRD] gave seed funding for five years. We were expected to establish the expertise in the manufacturing side and then slowly get the industry funding…

It emerged in this interview, however, that he had left this centre in the late 1990s to work full-time in a spin-off company set up by the first director of the centre a decade before, to market and develop the computational software which had been acquired from abroad. When asked why he had finally left, he noted:

> To some degree the emphasis at [name of centre] has changed slightly, my understanding was when I joined that they were trying to establish a number of permanent research positions that would drive the research at the centre. Whereas in the late ‘90s, my impression was that that emphasis has changed, that they were not interested in maybe permanent researchers any more, that they were more interested in post-doc types, you know a post-doc comes and works for a few years and then resigns. So, there wasn’t really a future for me as a senior research officer at [name of centre]. I didn’t see that [future]. And then the option would be for me to take an academic post, become a lecturer at the university and do research as part of that. And I was not really interested, so I took the chance to work full-time [with the associated company, where he still was at the time of interview in 2000, though appearing to find it difficult to obtain sufficient contracts from industry in that subfield]…

Significantly, only one of the 10 case studies (the Fluids Centre, Case 7) succeeded, during the entire interview period of 2000–07, in providing an employment
structure to retain senior researchers by offering medium-term research careers, let alone 'permanent homes'.

A further problem, quite complex but nonetheless implicit in some of the comments of the professors interviewed for Case 10, related to the role of postgraduate teaching as one of the three aims noted earlier. Did the loose agglomeration structure of Case 10 produce a weak collective research direction or mission, with the result that, in effect, the master's teaching programme became the main glue holding the network of professors together?

In 2000, the three academics of Case 10 who were interviewed all held strong convictions of the importance of their dual identity as what I have termed researcher-lecturers. For example, the new director in 2000 stated: ‘The point I want to make is one that we [academics affiliated to the centre] would all agree on. And that is that postgraduate research, and postgraduate students, are an absolutely vital and essential part of the centre…’

And the deputy dean, who was part of this Centre-as-Agglomeration and was supervising about 10 master's and doctoral students annually, commented even more strongly:

People [in the centre] will get research and they will get a consulting job… they may use the facilities [hardware and software of the centre] that sits there to do it, and they will pay for it. But that is not the purpose of [name of centre]. The purpose of [name of centre] is to train students and, if possible, to train them through industrial links…to train students, if possible, where you can get industrial-related projects...[and later continued] The courses [master's modules] might have changed slightly but they’re generally the same courses that were taught 20 years ago.

The last point demonstrates the two-decade continuity of input of the centre to postgraduate training in this subfield within the Faculty of Engineering. Moreover, these comments highlight the fact that in some ways these professors’ identities were still relatively close to that of Prof. Science in his small traditional (virtual) unit (Case 0), whose foundation was PBR and the teaching of postgraduates.

These tensions between the three goals – postgraduate teaching, PAR and UIBR – during the 2000 interviews seemed both a strength and a weakness. This became further apparent when Case 10 was revisited five years later.

A second visit to the Centre-as-Agglomeration in early 2005

It is useful to begin this section with a quote from a statement of the ‘Current Research Activities’, taken from the website of this centre in 2000:

The activities of [name of centre] thus represent a spectrum running from fundamental studies through to direct applications; while each [research]
project stands on its own to a large extent, the projects all gain from interactions with each other.

As already noted for 2000, the fact that the centre spanned the spectrum from UIBR to PAR was one of its strengths. Yet this was directly linked to the way each academic within the Centre-as-Agglomeration organised his funding: despite some pooling of funds, essentially there was an individual funding account for each constituent academic, who chose where to locate his research on this spectrum of UIBR–PAR, within a relatively wide area of computational analysis combined with engineering–science research.

Given this mode of organisation involving a ‘network of professors’, Case 10 lacked what might be called a strong collective research programme or common direction. It was thus what I have termed a new virtual centre (Model C) type structure, with the professors of this case having an especially diverse set of missions, linked to their research subfields and also their own identities and research orientations. Unlike the Model A centre type exemplified by the Agriculture Centre (Case 1), within the Centre-as-Agglomeration its director could not direct the research orientation of the cluster or network of academics that chose to be affiliated to this research centre. In contrast, in the Model A type there is both a designated centre mission and collective funds which in the last analysis the director ‘directs’ according to this mission.

Given both the strengths and weaknesses inherent in this agglomeration or network mode of organisation, it was interesting to find during the second phase of interviews in early 2005 that a recent official university research review of the centre had also noted some of these issues. For example, it was noted explicitly by the self-review document of this research grouping:

Members [of the centre] are agreed that the current set of activities amount to a collection of largely independent projects, so that there is no focal point to the work of the centre. The development of an appropriate focus requires a strong degree of commitment by [name of centre] members to work towards such a goal.

And it was commented further:

What is lacking though [despite noting strongly some unique projects involving international-quality research expertise], is a mechanism for generating funding that can be put to general use, as opposed to project-specific use, and which would make it possible to re-establish a core of research and technical staff.

Nonetheless, despite such problems, both the research review documents and the interview of 2005 revealed that in many ways the research grouping was as productive and relatively stable as it had been in 2000. For example, in terms of affiliated full-time academics, numbers were higher (12) than at any point since its establishment in the early 1980s, and nearly all the senior academics of 2000 were still there in 2005. The review report noted, too, that numbers of enrolled master's
(over 30) and PhDs (over 20) were high and that half of the students in each group of postgraduates were black (but overall, only one was female); in general, moreover, the centre was commended for the quantity and quality of its research.

**Early 2007: Interviews with two long-standing senior researchers of the Centre-as-Agglomeration**

In the 2005 interview with the director of this centre (who had also been acting as a full-time dean since the late 1990s), he made the following statement with respect to a key issue emerging from the research review shortly before:

> But, you know, the other weakness that we've identified is of a very, very concrete nature. We all agree, including me, that we are not going to achieve our objectives if we don't have a director who's able to spend a major amount of time on the centre, and who actually also will have a major physical presence, be around and so on. You know, [as dean throughout 2004] I haven't been to [name of centre] for about two months now.

This comment came to my mind again during the interviews in early 2007. He had remained director of the Centre-as-Agglomeration during the entire period of interviews, always under heavy time constraints as director and pulled in multiple directions as dean as well. Yet suddenly, at one point in the 2007 interview, it became apparent that all this was going to change quite substantially in the years to follow, for himself and for the centre. This was because he had just become a recipient of one of the 21 new national NRF research chairs allocated nationally at the end of 2006. Such a position provided at least R2.5 million research funding per year for five years, effectively enabling buyout from undergraduate and other departmental duties, so that he would be able to concentrate on research, including postgraduate thesis supervision linked to the chair. The interview revealed that he had recently stepped down as dean and intended to devote much of his time to his research work as director of the centre, using the research chair and its funding to enhance the work of this centre where possible.

Thus the situation of the Centre-as-Agglomeration in 2007 emerged as follows:

- Since my visit of early 2005, a few of the affiliated academics had left (mainly because they had left the university), but a few new ones had joined, so that in effect the number of academics who were part of the centre had remained constant; the number of postgraduate students had also remained fairly constant.
- Crucial changes were nonetheless on the way in 2007, especially with regard to the director's vision to: i) strengthen his own research subgroup within the centre, which would include using his research chair funds to pay for two or three post-docs, bursaries for a few doctoral and master's students, and also one or two research officers (more senior post-docs), if such persons could be found; ii) facilitate, as overall director, the linking up of his expanding subgroup with at least four or five other professors who were becoming, or were already, fairly strongly affiliated to the centre, so as to strengthen the core group of professors who made
up the ‘agglomeration’ of this centre; iii) sustain, in addition to this envisaged core network, a looser and less involved group of professors (10 or more) who were affiliated to the centre mainly because of the computational expertise associated with its broad area of engineering–science research work; iv) expand somewhat the existing small technical and administrative infrastructure of the centre; v) strengthen, where possible, the existing long-standing master’s programme by coursework and mini-thesis in the niche area of the centre; and vi) consolidate the system of bi-monthly staff–postgraduate seminars, so that the intellectual core, including the general research culture within the centre, could be enhanced.

Interestingly, too, it emerged in the interview that the director had, during his sabbatical leave abroad the previous year, visited a vibrant large university research grouping (in a similar area of his subfield of research), housed in a six-floor building with infrastructure and 12–16 research chairs spanning computation fields across mathematical, materials, biomedical, engineering, biological, etc. sub-areas of research (all funded by one alumnus, who provided for the building of a cafeteria on the ground floor, too, along with bursaries for PhDs). Clearly, such an overseas ‘institute’ was providing a stimulus for the director and others of Case 10 to push forward more clearly some of the vision for the centre in 2007.

A second interview, conducted with another senior professor affiliated to the centre who clearly appreciated the catalytic role which the award of the research chair was going to play within the centre, revealed support for aspects of this vision. This second professor saw his own research subgroup continuing under the umbrella of the centre, particularly because of the ‘cross-pollination of research ideas provided by interaction of professors and students in the centre’, as he put it. And he saw the award of the chair as helping to stimulate more industry funding and general support for the centre – since, in some of the years following the ‘high point’ of FRD and industry funding of the 1990s (again as he put it), there had been somewhat of a lull in funding and activity at the core of the centre. Moreover, with more PhDs and post-docs coming into the centre, this could help in relation to lecturing of master’s courses in the centre’s postgraduate programme. ‘The NRF chair is wonderful for all this,’ he noted.

In conclusion, following my 2007 round of interviews at the Centre-as-Agglomeration I had to revisit some of my doubts after the first and second phases of interviews about the characteristics of a loose agglomeration of high-quality research professors within such a Model C type of ‘new virtual centre’. In 2007 it became clear that, under certain conditions, such a mode of organisation could actually take forward a viable and innovative research enterprise. While the Space (Virtual) Centre (Case 3) did seem to be more ‘solid’ in 2007 – because all its professors were based in a single engineering department – nonetheless, the Case 10 agglomeration or network of professors across a range of departments (of two faculties) seemed to be progressing nearly as well. This Centre-as-Agglomeration had struggled on for nearly a decade when its director served as dean, but now seemed about to receive an injection of new energy linked to the award of the research chair and its funding. Conversely, the third
phase of interviews showed that there clearly still were, and would continue to be, problems with such an agglomeration: each professor was responsible for his or her own core funding, and to some extent pulled in diverse directions; this might even be accentuated by the power of the subgroup around the chair. In addition, there remained questions of how effective such an agglomeration had been in terms of responding to industry needs, and how centre funding might be directed not only to the newly expanding group around the director, but also to the diverse subgroups constituting this relatively loose network of professors (all of whom, it should be stressed, had substantial teaching duties in 2007, except the director-cum-chair holder).

It is important to recognise that in the current South African university context, new real research centres like the Agriculture Centre (Case 1) along the lines of Model A are underfunded, poorly conceptualised and structurally underdeveloped. Thus, as will be argued in the next chapter, unless new South African research policy initiatives are instituted soon, we can expect relatively few such real centres to survive and flourish with a common research direction and mission. In this situation, a loose agglomeration or network of existing, tenured professors, with different subgroups and research agendas, does suggest possibilities for development. Therefore, Part 2 concludes with the following question: in the current situation in South Africa, where research groupings at universities are significantly unstable (as is evident from the 10 use-oriented case studies presented in Chapters 4 and 5), does the Model C-type structure of a network or ‘virtual centre’ hold some promise for high-quality UIBR and PAR, within an expanding second academic transformation in our country? In Part 3, I turn to a consideration of this and related questions.

Notes

1 As noted in Chapter 4, the vast majority of directors and senior researchers of all 11 cases were male, and therefore for ease of reference (unless stated otherwise) the term ‘he’ will be used instead of ‘s/he’.

2 Information from the departmental website, accessed in July 2000.

3 Professor Biogenetics used the terms ‘my group’ and ‘my lab’ interchangeably.

4 The CV of Professor Biogenetics, besides providing a description of extensive links with industry, also showed a long list of joint publications with postgraduate students and co-researchers over a period of almost three decades, many with a fundamental research theme and published in leading international science journals of his subfield.

5 A view emerging from the interview in 2000, and also from a paper published by Prof. Biogenetics about this shift to PAR after the 1980s.

6 In 2000 the departmental website listed eight ‘research groups and interests’ and stated with respect to the department’s research: ‘most projects involve in-depth fundamental research into problems which have applied relevance. This combination of academic and practical approaches has attracted support from the FRD and industry.’

7 Some components of the research work in Prof. Biogenetics’ lab, in addition to UIBR, might be better categorised as PAR (in Stokes’s terms, oriented towards a specific problem in a defined context), but I have not elaborated on this here.
These books were also oriented towards interested professionals within industry and government organisations, both internationally and in South Africa. The point, however, is that for Case 4 there was also some orientation towards public opinion-making civil society groups and organisations – something not usually found among the other case studies.

In other words, P would retain only 10 per cent of his academic duties.

As previously noted, the term 'university of technology' will be used throughout to refer to HEIs that moved from technikon to university of technology status, unless otherwise specified; in this particular case, during the first phase of interviews this institution was designated as a technikon.

See Cooper and Subotzky (2001: Chapter 1) for a brief history of the technikons, which began in the 1960s as 'Colleges of Advanced Technical Education'; see also the Introduction to Part 2.

The merger of the two Cape Town technikons to form a new UoT began to take effect after 2004 but, even by early 2007, this had not yet had a significant impact on the research culture within either institution, including in Prof. Commerce's department.

Even after the early 1990s introduction within the technikon system of the fourth year add-on BTech degree and the M Tech and DTech, by 1998 over 90 per cent of all students enrolled at this HEI were still registered for the three-year National Diploma qualification (derived from Cooper & Subotzky 2001: 168). This obviously had an enormous effect on the research culture of this UoT right up to 2000 and beyond.

Newspaper feature article of early 2000 (unnamed and undated for reasons of anonymity).

See Figure 2.2 in Chapter 2, which illustrates the 'Investigation Work Spectrum', with 'routine consultancy' (no new knowledge production) on the far right side.

(Ex-)UoT staff are in general considerably less qualified than those of 'traditional' universities. For example, in 2000, 5 per cent of the permanent academic staff at South African UoTs had a doctorate and 24 per cent only a master's degree, compared to 41 and 31 per cent respectively for those at the traditional universities (Gibbon & Kabaki 2002: 210–211).

For government subsidy purposes, 'accredited journals' refers to the official Department of Higher Education annual listings of 'recognised peer-reviewed journals'.

'Primarily' has been added here, since throughout the second interview, Prof. Commerce characterised some of the investigation work he was doing as 'action research'.

The new system of NRF rating for researchers, which had been set up by the time of this 2007 interview, meant that an NRF rating was becoming important for someone seeking professorial status at all HEIs, including at this UoT.

Information on the origins and consolidation was provided mainly from the interview with the director in 2000 and from interviews at that time with two other researchers, as well as from documentation obtained from the research grouping and its website. The interpretation of reasons for fragility and instability are mine, not those of the grouping, although subsequent interviews did confirm much of this interpretation when it was explicitly put to persons within or associated with the grouping.

This research grouping will be referred to here as a research 'unit' from its inception in the 1970s until its constitution as a formally designated 'research unit' in the mid-1980s. I will
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refer to it as a 'centre' from the late 1980s onwards, however, because its internal structure developed in a similar way to that of the Agriculture Centre (Case 1 in 2000).

22 Within this university, this term was used up to the 1990s.

23 For a short period during the 1990s, the research unit was formally responsible to a university 'outreach committee' – because it was viewed as doing 'outreach' of a more applied nature, and was therefore not primarily accountable to the university research committee.

24 The Centre of Development Studies (CDS) at Natal University, which was consolidated in the 1990s and modelled along the lines of the Sussex University CDS, was just such a structure, with over six tenured academics undertaking research and postgraduate teaching, supported by a larger group of contract researchers. But this model has been very uncommon among South African universities, even up to the present. (I am indebted to Professor Mike Morris, previously of the Natal CDS, for bringing this case to my attention.)

25 Information from interviews and personal observation.

26 It is pertinent to specify gender here, as a considerable proportion of untenured research workers in these research groups in South Africa (and internationally) are women.

27 Part-time consultants from outside, and tenured academic staff from within the allied department, were frequently brought in to undertake specific work for clients, and the two directors (both holding doctorates) played crucial roles, too. Nonetheless, the research work of these master's-level researchers to a significant degree formed the anchor of the Sustainability Centre.

28 The self-review by the Centre in 2005 mentions that, since the mid-1980s, it had delivered almost 100 short courses and trained over 1 000 professionals.

29 The self-review by the Centre mentions that this advisory unit had to be ‘a self-funded sustainable entity’ and that no funding was available from the university itself.

30 In 2000 there had been 13 (including three administrators) compared to the 15 in early 2005. Previously, though, during the 1990s, the size of the research group had more or less doubled to reach the 2000 level.

31 Besides the two co-directors, in early 2005 only two of the six researchers who had been there in 2000 were still at the Centre, and eight new researchers had joined.

32 The fact that this was a ‘white male’ is made explicit here and in his story and interview quotes which follow, because in the post-1994 period government employment equity criteria (giving priority to historically disadvantaged applicants) have often made it difficult for white men to obtain permanent positions in universities and other organisations. His story highlights, in extreme form, the problems faced by all contract researchers at our universities.

33 Such contracts at this university implied that retrenchment would be legal only if the Centre's funding ran out or if major restructuring took place.

34 For this reason, senior management at the UoT (still a technikon at the time) strongly recommended that these two be the focus of our investigation, a request that was adhered to (see Appendix 1).

35 Only recently have these (now) UoTs been attempting seriously to develop master's and PhD enrolments. Data show that, in 2003 (just prior to the merger dynamics), the 15 UoTs still made up only 3 per cent (around 250 in terms of absolute numbers) of all doctoral
enrolments and 9 per cent (around 4 000) of all master’s enrolments, in comparison with the 21 universities at which the remainder enrolled (derived from Koen 2006: 35, Table 2).

36 Up to this point all academic posts at the UoT were designated as ‘lecturer’ positions.

37 As general laboratory manager within the department, he was in part funded by the UoT in 2000.

38 During the first interview with Prof. Fluids, I participated together with my research associate Dr Sharman Wickham. Dr Wickham thereafter undertook follow-up interviews with Prof. Fluids and researchers A, B and C in 2000.

39 I am indebted to Dr Wickham, whose written notes and informal discussions with me about this workshop helped to clarify the nature of some of the core problems, which various members of the group articulated. See also Cooper (2003b), where these problem areas were first analysed in the report to the Trade and Industrial Policy Secretariat following the first phase of interviews.

40 As agreed by Prof. Fluids during the second phase of interviews, this ‘permanence’ was de facto dependent on long-term industry contract funding for his Fluids Centre as a whole, since if a research grouping like this Centre were to be dissolved or completely restructured, such tenure was not necessarily legally binding on the UoT. (Note, however, that this also applies to tenure for lecturers in a department of a South African university, where academic departmental restructuring or dissolution enables the tenure of an individual to be legally withdrawn.)

41 I specifically mention here this female senior researcher who had also become assistant director, to highlight in this case the substantial components of transformation undergone by this Centre, within moreover a historically male-dominated UoT.

42 A ‘C1 rating’ by the NRF is based primarily on the criterion of ‘national recognition of the researcher’.

43 The technikon institutions had emerged in the 1960s out of the technical college system, and while they underwent various changes of form and structure over the years (see Cooper & Subotzky 2001 Chapter 1), they continued with a system of four teaching breaks or holidays per year (like the colleges and high schools).

44 Information obtained from this engineering department brochure of 2000.

45 This niche programme, for reasons of confidentiality of the case study, cannot be specified – but it involved science–engineering methods of development and optimisation for sectors of the South African mining and manufacturing industries.

46 In Cooper (2003b) after the first phase of interviews, these potential problem areas were already identified. As will be seen, such problems had clearly begun to emerge by 2005.

47 This important conclusion about its core business, based on the interviews and documents of this case study, was initially suggested in a draft ‘Overview Report’ written in 2000 by Dr Sharman Wickham, who undertook the data collection for the case study with the assistance of Ms Carlene Davids.

48 The report cited here is Cooper (2003b).

49 Note that although the Fluids Centre was formally within the department of Prof. Fluids, it had achieved a high degree of autonomy by 2005.

50 In 2007, the two colleagues called their research grouping a ‘unit’ in their ‘lab’.
51 Although in the interviews and documentation it was recognised as an official ‘centre’ of the UoT, I shall at times refer to it as a ‘virtual’ centre because, as will be seen, it never became consolidated as a functioning Model A centre type.

52 Numerous academic staff of this UoT at the time were also registered for an MTech or D’Tech, but on a part-time basis.

53 Note that these figures were for the year 2000. By the end of 2007, the NRF scholarships for PhDs had more than doubled from this 2000 level. See, however, the discussion in Part 3 of the experience in the sociology department of UCT, when a PhD scholarship to the value of R120 000 for four years (i.e. worth nearly half a million rand overall) was advertised in 2007 – for which we received very few black African applicants from South Africa.

54 It seems that the late 1980s saw the FRD encouraging the formation of ‘research centres’ as a new initiative, though further research is needed to examine these national initiatives and results.

55 I was at the Cape Town conference on postgraduate education in the late 1990s where this unpublished paper was obtained. I am also indebted to a colleague of his, in this engineering research centre, for providing me with a published 'Bibliographical Essay' on this research leader and innovator, which provided valuable information on the life of this man, which is incorporated into some of the analysis of these paragraphs.

56 Note that these ‘survey courses’ (unlike the doctoral-level courses offered in the USA) were only offered at master’s level (never at PhD level) by this Western Cape research centre because, as this director commented in his paper, ‘In [the name of his research centre] we have…not had the resources to introduce more advanced [PhD] level courses.’ The absence of academic resources for PhD-level coursework at South African universities, and the consequent lack of a ‘broad appreciation of the discipline’, will be discussed further in Part 3.

57 The website of this centre was accessed in August 2000 and in January 2007. I base this summary on an assessment of the components of its mission described on this website.

58 Listed on its website (accessed August 2000), publications from the early 1980s (establishment of centre initially as unit) onwards.

59 A significant number of these were produced by master’s and doctoral students, linked to their thesis work.

60 In fact, it was this insightful comment by the new director – himself an internationally recognised ‘engineering-cum-science’ research expert embodying the pure/applied dichotomy within his own subfield – that influenced my thinking about what I termed ‘fundamental-applied’ research at the time (early 2000s) and its differences from what was then the more dominant term in South Africa, ‘strategic research’ (a term which seemed to confuse more than assist in conceptualising these complexities). I am thus indebted to this new director for his ideas in 2000, including the point about 'development work' (which in this study I have termed 'routine consultancy' work), as they made me more receptive also to the idea of UIBR later in 2005, when I first encountered the work of Stokes (1997).

61 And even in the case of the Fluids Centre, as noted earlier, its director agreed that, if his Centre lost most of its funding for any particular reason, it was legally possible, by means of restructuring, for his UoT to declare his two newly acquired permanent positions of ‘senior researcher’ redundant.
Website accessed August 2000.

Most of the data relating to the 2005 visit to this centre are derived from the report documents of this review (kindly made available) as well as from the valuable interview with its director.

Of note also was that according to the research review, hardly any of the researchers linked to the centre were female.

Part of the funding allocation of these NRF chairs includes grants for master’s and doctoral students, the aim being for the chair holder to help in the development of a new generation of young South African researchers and academics. Some of the R2.5 million is also a contribution to the salary costs of the chair holder, whose university is required to replace her/him with another lecturer within her/his department for the five-year period. Note, too, that with possible renewal for a further two periods of five years each, such a chair-ship is possible for 15 years in total, providing for substantial continuity.

This large research grouping at a university abroad was known as an ‘institute’, reflecting either a very large ‘centre’ or even a ‘collection of centres’ (in terms of the definition of ‘centre’ which I proposed in Chapter 3).
PART 3

Drawing together the threads from the 11 case studies
Another look at the second academic transformation

The theoretical framework presented in Part 1, with its central proposition of a second academic transformation symbiotically linked since the 1980s to a third capitalist industrial revolution, provides the focus in this chapter for a drawing together of the threads of the 11 cases presented in Chapters 4 and 5. Hence the importance of first reviewing the core underlying issues, perspectives and questions related to this framework.

In the Introduction to Part 1 and Chapter 1, I highlighted three hypotheses of Etzkowitz with reference to academic transformation and the three missions of university activity. These hypotheses propose, in essence, that:

- a third mission of socio-economic development has emerged alongside the two earlier university missions of (basic) research and teaching;
- this transformation (what Etzkowitz refers to as a ‘revolution’) is part of a new triple helix of U–I–G research relations; and
- a new academic ethos combines in creative tension both ‘fundamental’ and ‘applied research’.

I also proposed that these hypotheses should be viewed as part of a fundamental second academic transformation which is even more revolutionary than Etzkowitz claims. This is because they are producing very deep transformations in universities relating to research structures and values, and are giving rise to new academic systems and norms including new model types of research organisation. I also proposed that this was linked to a form of research best categorised (following Stokes 1997) as UIBR, itself governed by the dynamics of the U–I–G triple helix.

Let us look again briefly at the individual case study data of Part 2 in the light of these propositions. As regards the idea of a triple helix, an assessment of the 10 use-oriented cases points to a very strong dominance of U–I–G research relations. In every case except that of the Commerce Unit (Case 5, whose professor was involved in research and training linkages with local government bodies in addition to his work with industry), industry appeared as a dominant external partner in the research grouping’s third mission. For example, the research undertaken by the Agriculture Centre (Case 1) was closely connected with, and funded by, what I termed its ‘Agri-Sector Industry Network’. Similarly, both the Space Centre (Case 3) and the Genes Unit (Case 2) had spin-off companies located near their universities – companies active in commercially developing products that emerged from the
research work of these university groups. Across the cases, all the research was linked in significant ways to different industry sectors and firms. In fact, it was noted that only the Sustainability Centre (Case 6) had, through its research work, purposefully developed some important links with neighbouring civil society organisations. Almost all the other cases were observed to have no links, or only minor ones, with external partners outside industry. Thus it seems that U–I relations have been central to third mission developments in the Western Cape, perhaps even more strongly than Etzkowitz had proposed.1

At the same time, in all 10 use-oriented cases the first mission of teaching had remained very important, supporting Etzkowitz’s hypothesis that the third mission was being ‘joined’ to the earlier two missions. Admittedly in some cases, such as the Genes Unit and the Sustainability Centre (and the Agriculture Centre, before its reconnection to an academic department in 2004), the focus had shifted mainly or entirely to postgraduate teaching; but most of the others were significantly involved in undergraduate teaching as well, despite some clearly observed tensions between the first and third missions (see below).

What of the relationship between what I have termed the older second mission of basic or fundamental research, and the new third mission of socio-economic-cultural development?2 As I argued in Part 1, and the case studies in Part 2 demonstrated, it is important to apply the concept of UIBR in order to capture a central dynamic here. For example, it was observed how the Agriculture Centre focused on its UIBR rooted in basic microbiology research, but with important biotechnology applications in its agricultural sector. At the same time, a lesser part of its work was better described as PAR, with the focus on specific problems for the new biotechnology company with which this centre became linked. In the Genes Unit, too, despite close links with its allied company, UIBR still dominated its university-based work.

The director of the Centre-as-Agglomeration (Case 10) expressed this relationship clearly (with reference to his focus on what was essentially UIBR plus some PAR, rather than on contract-based development work – what I have termed ‘routine consultancy’ – that was also carried out in his centre):

If I can come back to your question about basic and applied research, I almost prefer not to make that distinction…The kind of distinction that I would make is between research – whether it’s pure or applied – on the one hand, and development work…[We] get a research contract, a job that has to be done; we do the job. There’s nothing particularly original about it. (Cited in Case 10)

An examination of the 10 use-oriented cases does show that some, particularly the four cases located at UoTs, appeared to have a relatively greater focus on PAR work. Yet even here, for example in the Fluids Centre and the Centre-in-a-Faculty, there were some professors in each grouping who were pursuing what was clearly UIBR. Moreover, most of the university research groupings were found to be oriented primarily towards UIBR (e.g. Cases 1, 2, 4 and 10), and only one of the 10 use-
orientated cases – the small unit of Prof. Commerce (Case 5) at a UoT – could be said to have focused entirely on PAR work.

In summary, therefore, it is proposed here that the 10 cases of use-oriented research work are best conceived as a complex combination of UIBR and PAR. This also confirms what I argued in the Introduction to Part 1: that during my research I found the dichotomy of ‘pure’ and ‘applied’ unhelpful, and even the concept of ‘strategic research’ or the idea of Gibbons et al. (1994) of ‘Modes 1 & 2’ did not capture these complexities sufficiently sharply. Eventually, after the second phase of interviews in 2005, I held fast to the new idea that UIBR provided a better understanding of what was going on in most of the Western Cape case studies, and particularly at the three universities.

In addition, what was characterised in my introduction to Part 1 as the ‘relative autonomy’ of university use-oriented research vis-à-vis the industry with which it is linked, was seen to have been sustained fairly rigorously in most cases in Part 2. For example, in the Introduction to Part 1 I cited the Space Centre, whose core professors – with MIT and Stanford backgrounds – sought to carry over the lessons learnt at these American universities about how to maintain what the one professor termed an ‘artificial wall’ between the new knowledge-seeking work of the university Space Lab on the one hand, and the more routine commercial development work of its allied company lab on the other. In other cases the concern to maintain such a line between university and industry research work was also clearly evident: for example, the directors of both the Agriculture Centre and the Genes Unit argued explicitly that their pursuit of academic research in the university was based on the desire to maintain strong, new knowledge components in their UIBR and their PAR, and to maintain a ‘division of labour’ between their university-based work and the work in allied companies. Similar ideas and actual practices were evident in the other cases: for example, Prof. Biogenetics of Case 4 eventually eschewed some of the more PAR side of his unit’s work in order to write research-informed books on biogenetics, while the directors of all three virtual centres (Cases 8–10) were observed to be oriented towards internationally recognised, strong university-based UIBR and PAR work. Only for Prof. Commerce (Case 5) was there some discussion of a potential drift towards PAR and even some routine consultancy work.

The evidence from the Western Cape case study data suggests, therefore, that it is certainly possible under the new conditions of a spread of third mission activities, linked to a global second academic transformation, to maintain a division of labour – if professors are committed to this – between good academic research work in the university and the more routine development work in industry labs. There is little evidence, at least from the case study data here, for a strong drift, under pressure of industry funds, towards the shedding of quality research work. On the contrary, as argued with reference to TNCs and global capitalist trends in Chapter 3, and also as is evident from the Western Cape cases, industry which is aiming to be innovative is usually clear that what it needs most from universities is good, high-quality research – it can achieve the more routine work in its own labs.
Thus, it appears clear that there is convincing evidence from the Western Cape cases for what has broadly been characterised in Part 1 as a new international second academic transformation, and for the validity of the first three Etzkowitz hypotheses cited above, and my own related hypotheses about UIBR, PAR and a strong triple helix dominance.

What of the other Etzkowitz hypotheses outlined at the beginning of Chapter 1? Etzkowitz proposed that the second academic transformation/revolution has led to universities changing in the following ways:

- They are becoming a primary, not secondary, institution of society.
- This is a result of their central role in facilitating national economic competitiveness (vis-à-vis other countries).
- Moreover, they are increasingly orienting their third mission activities towards regional development (as well as national development).

To what extent do the Western Cape case studies support these three propositions? Interestingly, the 10 use-oriented cases suggest that in these three respects South African university third mission research activities are less advanced along the path of such a second academic transformation, in relation to some comparative evidence presented in Part 1 concerning research-intensive universities in the USA and Europe, and even in certain Asian countries. In the Western Cape case studies, for example, the director of the Agriculture Centre was the only one to stress the vision of his centre providing competitive cutting-edge research for its Agri-Sector Industry Network, to support its international competitive drive relative to similar agricultural products in the global economy. At the same time, the universities’ research role in enhancing South African industrial competitiveness was not entirely absent from the discourses of other Western Cape research directors and senior researchers during my interviews. Often implicitly, and at times explicitly, it was stated that the research work ‘made a difference’ to their various industrial clients.

In contrast, the international data in Part 1 indicated what I called a kind of urgency, a significant ‘innovation anxiety’. This was expressed, for instance, in terms of university research being ‘essential for economic competitiveness’ – as in the European FPs (for example, the Lisbon Declaration of 2000, cited in Chapter 1), or in an interview (cited in Chapter 3) with Erich Bloch, the head of the American NSF, relating to the American ERCs in the mid-1980s. Such expressions of innovation anxiety did not appear as strongly in the Western Cape interviews. Although these interviews suggest that they saw the importance, even the increasing importance, of their research work being linked to industry – both for its valuable outputs and for the research funding it provided for their research missions – the industrial importance of university research was viewed often in vague and generally diffuse terms. In particular, there appeared to be very little idea (up to the third phase of interviews in 2007) that there is a major second academic transformation unfolding globally, which is itself linked to an international industrial revolution ‘seeking out’ university science.
As regards the issue of regional economic development, only the directors of the Agriculture Centre and the Sustainability Centre explicitly expressed any ideas about the research work of their centres linking up with regional (Western Cape) socio-economic development. In contrast, all the other research directors appeared to see their main role as linked to supporting industry in general, that is, nationally. This suggests that the centrality of university research for the industrial competitiveness of the Western Cape had not yet emerged as a dominant concern among the case studies investigated; nor was there the degree of ‘regional’ innovation anxiety that can be observed to have been emerging at universities in the USA, Europe and Asia.3

In summary, therefore, regarding the Etzkowitz hypotheses, it is clear that a generalised consciousness of U–I research relations, and their value for the research future of all (or most) of the cases, was undoubtedly present and strong. All 10 use-oriented research cases showed directors actively seeking to pursue and construct research funding linked to industry, albeit more often at national than at Western Cape level. However, in the majority of centres and units there appeared to be a relative absence of innovation anxiety linked to issues of university research and economic competitiveness. As a corollary to this, there was an absence of the idea of a global new academic transformation, as well as an absence of specific discourse about a knowledge economy associated with what I have specifically called a new (third) industrial revolution.

The implications of these absences – both theoretically ‘in the minds’ of researchers and also with regard to certain weaknesses of South African research policy initiatives at universities – will be considered further in Chapter 7. What is important to stress here, however, is that because there was very little awareness of a second academic transformation enveloping these 10 research groupings, there prevailed in all of them various degrees of what I have termed ‘chaos and creativity’ in their research work. The latter included a set of diverse but largely unrecognised – and hence confusing – conflicts and contradictions between the research structures and values of the new academic transformation and those of an older (first) academic transformation. This provides the major theme for the discussions below, which focus on these ‘micro-contradictions’ linked to the third mission research work in the 10 cases themselves.

Specifically, the next section of this chapter focuses on what I term micro-contradictions in the internal organisational structure of the research groupings, analysed in terms of model types (Models A, B and C). The final section focuses directly on a range of specific factors (e.g. weak funding and the absence of a career track for researchers), which, I will argue, create further micro-contradictions and thereby inhibit the research work in the various Western Cape cases investigated.
Internal modes of research organisation: Findings from the case studies

**Figure 6.1 Modes of organisation of use-oriented groupings: Models A, B and C**

- **MODEL A**
  - New (Real) Centre
  - (exemplified by Case 1: Agriculture Centre)
  - Professor-director,
  - Senior researchers & their subgroups,
  - Postgraduates & a few post-docs in each subgroup,
  - Centre administration infrastructure,
  - Research programme & some clients,
  - In an academic department or faculty/school

- **MODEL B**
  - New (Real) Unit
  - (exemplified by Case 2: Genes Unit)
  - Professor-researcher,
  - Postgraduates & a few post-docs,
  - Sometimes in a lab,
  - In an academic department or faculty/school

- **MODEL C**
  - New (Virtual) Centre
  - (exemplified by Case 3: Space Lab)
  - Professor-researchers & their subgroups,
  - Postgraduates & a few post-docs in each subgroup,
  - In a lab or labs or groups,
  - & some clients
  - In an academic department or faculty/school

- **MODEL T**
  - Traditional (Virtual) Unit
  - (exemplified by Case 0: Science Unit)
  - Professor-researcher-lecturer,
  - Postgraduates & a few post-docs,
  - Sometimes in a lab,
  - In an academic department

Differences between a new real centre (Model A) and a new real unit (Model B)

The various case studies have highlighted how the Model B unit type has been constructed out of the traditional elements of the first academic transformation of the nineteenth century that produced the Model T unit type. Such a unit would consist of a professor working alongside her/his master’s and doctoral students, sometimes with one or two post-docs, in a small research grouping (often referred to as ‘my lab’ or ‘group’). The main difference between the traditional Model T and a new real Model B unit, therefore, lies not in their core internal structure (see Figure 6.1) but rather in their dominant research orientations: whereas Model T is PBR- or curiosity-oriented, Model B is use-oriented (towards UIBR and/or PAR). Research in Model B groupings (exemplified by the Genes Unit of Case 2) is linked to ‘clients’ or external stakeholders who value such research outputs. Other cases hypothesised as being ‘in transition’ between Model T and Model B – Case 4
(the Biogenetics Unit) and Case 5 (the Commerce Unit) – were observed to have a similar internal organisational structure and were also linked to various clients for their UIBR and PAR work.

Prof. Genes provided an important example of another feature present in this shift to third mission work: in his interview he made it clear that he was involved only in postgraduate teaching and supervision, so his main academic identity was clearly that of a researcher, rather than a ‘researcher-lecturer’ – the identity of Prof. Science (Case 0), an exemplar of a traditional Model T professor. In the ‘transitional’ Cases 4 and 5, Prof. Biogenetics and Prof. Commerce had not yet shed undergraduate teaching, although their additional third mission work was clearly putting some strain on their overall teaching and other traditional departmental activities.

Comparative analysis of the Agriculture Centre and the Genes Unit suggested that there are two main differences between the core internal structures of Model A and Model B. Firstly, the Agriculture Centre had a vital layer of senior researchers who led at least three or four subgroups in a large centre-type grouping. Secondly, the Agriculture Centre had a sizeable administrative and technical personnel layer – at least three or four people who provided an essential infrastructure for the functioning of a large centre-type research grouping.

At South African universities, particularly among researchers seeking to construct larger centres, these two components are often overlooked. Such an absence contributes to the problems experienced by larger research groupings, whether they are operating as real or virtual centres. It was seen, for example, that even in the relatively well-organised Space (Virtual) Centre (Case 3), the lack of personnel infrastructure for its large microsatellite project put an enormous strain on the network of professors, despite their initially trying to get help from the ‘normal’ departmental administrators. The leader of the Centre-as-Department virtual centre (Case 8), a grouping of all the academics in the department, also struggled to find time to deal with all his administrative duties. It became clear, moreover, that a deficient administrative and management infrastructure for research activities had contributed to the fragmentation of this grouping into smaller units in the department.

Thus a Model A centre, in particular, seems to require an administrative layer or infrastructure not unlike that of a sizeable academic department in order to achieve viable research outputs for its clients or external stakeholders. Even more crucially, such a centre requires a layer of senior researchers, who are often mistakenly confused with the post-doc layer typical of a traditional (and new) smaller unit. The roles of senior researchers and post-docs are different, however, and if this is not recognised, enormous problems can arise for the Model A centre. Senior researchers are required to manage and lead substantial research subgroups, which are usually much like a traditional, small research unit in size and complexity. As noted in Chapter 3, internationally such a ‘senior’ is best conceptualised at the level of associate professor or professor, usually a post-PhD researcher, 35 to 45 years old or older, with some years of experience in the research niche area of her/his centre.
The Sustainability Centre (Case 6) – at a university whose senior layer at least up to 2005 consisted mostly of young researchers holding only master’s degrees – provided a good case study of some of the problems arising in such an under-qualified centre. Similarly, in the case of the Centre-in-a-Faculty at a UoT (Case 9), the inability of the engineering dean to recruit more senior researchers into the senior layer, or the position of director, appeared to be a central reason for its lack of consolidation and growth after 2000. The opposite was observed in the case study of the Fluids Centre (Case 7), which showed how its innovative director had managed, despite a weak research culture at his UoT, to build up a layer of three senior researchers by 2005, all with PhDs and experience. By 2007 these seniors were successfully leading their own research subgroups. Moreover, Prof. Fluids, as director, had achieved tenured research positions, with virtually no undergraduate teaching duties, for two of these seniors at his UoT. This was an achievement not found in any of the other case studies of centres, where the only tenured positions were for ‘researcher-lecturer’. This strong senior layer had made possible considerable growth and consolidation of the Fluids Centre as a new real centre along Model A lines, even though earlier in 2000 this grouping had been observed as a smaller Model B-type structure.

Among all the larger, centre-type structures there was not a single case that did not point towards this crucial factor: that for a viable and stable Model A new real centre (or even a relatively stable Model C virtual centre) involved in the serious undertaking of UIBR and PAR, a solid layer of senior researchers is absolutely essential. It is important therefore to recognise that the second academic transformation is giving rise to a new Model A type: an internal structure that includes a special layer of senior researchers, below the centre director but clearly above the layer of relatively inexperienced post-docs.

The value of a larger Model A centre type for use-oriented research

One of the disappointments of this study was the fact that, by early 2007, only one of the 10 original use-oriented research groupings still existed in a relatively stable Model A form – as a new real centre – organisationally separate from an academic department, in other words, with a director having autonomous control over its research mission and finances. This was the Fluids Centre. Here Prof. Fluids – although still working in the framework of the formal location of his grouping in his engineering department – after 2000 set out to build a larger, innovative and dynamic research centre around himself (with a new designation as director). In fact, as observed, Prof. Fluids had been influenced in realising this vision of a Model A centre type partly by discussions about my own study and the ideas emanating from this about a second academic transformation and the emergence of larger centre-type structures with a third mission led by a director. Thus by 2007 Prof. Fluids had secured two tenured senior researcher positions in his grouping, as well as five administrative–technical posts to provide the necessary infrastructure for the centre. And for himself he had secured release from his position as head of the engineering department as well as from most of his teaching duties. Admittedly,
this centre’s core PAR work for industry was rooted in a niche area where there was demand for applied research outputs, and hence industrial companies were the source of substantial and ongoing funding. Such financial security undoubtedly contributed to the Fluids Centre’s relatively stable centre-type structure by the time of the final interview.

In contrast to this, by 2005 the Agriculture Centre – which had seemed in 2000 to be the most stable of the Model A-type research groupings – was seen to have ‘reversed’ from an independent centre into a combined centre-cum-department structure, despite the fact that this centre had received major funding from its industry partner organisation. As shown in the analysis of Case 1, there were numerous reasons for this reversal, including the departure of the director and the most senior researcher soon after 2000, as well as the fact that the industry network funding seemed much less secure than in the late 1990s. By 2005, the Agriculture Centre’s four other senior researchers had all secured tenured posts back in the neighbouring department – which included undergraduate teaching and administrative duties – despite the fact that in 2000 the director had outlined clearly the advantages of having his centre outside any departmental structure.

One conclusion drawn at the end of the analysis of Case 1 was therefore that, in the current South African context, stand-alone research centres of Model A type appear to be especially fragile. This assessment was reinforced by the analysis of a few other Western Cape cases, where attempts to construct a viable and larger structure along the lines of a Model A type did not bear fruit after 2000. One such case was the Centre-in-a-Faculty (Case 9), where the vision of its UoT engineering dean to construct a ‘centre for applied technology’, with a director and group of senior researchers, never became a reality. By 2007 all that remained were a few (though viable) separate small research groups based around individual professors in the Model B modality of the Genes Unit. As regards the Centre-as-Agglomeration based at a research-intensive university (Case 10), my analysis showed that it had never functioned as more than a loose grouping or network of mainly engineering professors, from its origin in 1980 until the third interviews of 2007. In comparison, for over two decades the Sustainability Centre (Case 6) functioned effectively and productively as a relatively large Model A centre type (though always formally part of a department, with its director also serving as HoD). Yet the analysis showed that its layer of seniors consisted almost entirely of researchers holding only master’s degrees, hampering its capacity for UIBR and even PAR over the years.

It has to be accepted, therefore, that the data from the cases of this study consistently reveal a significant set of barriers or negative factors affecting attempts to build up a viable, organisationally bounded Model A-type structure. Moreover, there seems to be little clear understanding in South Africa at present of the need to build such ‘stand-alone’ (organisationally autonomous) larger centres at our universities and UoTs. A good example of this was seen in the 2004 university review of the Sustainability Centre itself, in which the university clearly failed to appreciate its innovative potential as an independent, use-oriented research centre.
My conclusion is that there generally does not seem to be an appreciation among research policy-makers (both in and outside universities in South Africa) that a Model A centre-type structure is significantly different structurally from a smaller Model B unit-type structure and also from a larger Model C-type ‘network of professors’. In addition, there seems to be little understanding that modes of organisation such as the Model A type are linked internationally to a second academic transformation and associated new larger centre-type structures. Equally worrying is that the post-2005 initiative by the NRF and allied governmental organisations (e.g. the DST and the Department of Trade and Industry) to support the development of up to 210 research chairs nationally will probably consolidate smaller units along the lines of a Model B-type structure (and in some cases perhaps a ‘network of chairs’ along the lines of a Model C-type structure) – instead of building new and vibrant Model A-type centres. All these propositions will be examined further in Chapter 7, which addresses more directly these ‘absences’ in both theoretical perspectives and research policy initiatives in South Africa generally.

I turn now to a more detailed consideration of some issues relating to the ‘efficiency and productivity’ of a Model A-type structure. This theme was introduced in Part 1 in relation to the spread of CoEs internationally, and needs to be examined more directly with reference to the Western Cape cases.

It must be stressed that smaller Model B-type units, and also Model C-type loose networks of professors, are able to achieve significant and high-quality research outputs of use-oriented research. This is why my underlying argument is that we need to encourage and build all three types simultaneously. However, in doing so, the specific strengths of the Model A centre type need to be recognised. I argue that the Model A type is particularly functional in serving the needs of the range of clients addressed by the third university mission in a new knowledge economy and society – industry, government and civil society.

In terms of ‘efficient functionality’, a first point to make is that the Model A type of organisation has a strong director who controls and shapes an overall programme for the research subgroups led by the senior researchers. This was the situation, for example, at the Agriculture Centre before its director departed shortly after 2000. Here it was observed that two broad research sub-programmes in agri-biotechnology set the framework of research for all four research subgroups. Thus everyone was locked into these two complementary research directions, essentially set by the centre research director in conjunction with the Agri-Sector Industry Network (which provided over 90 per cent of the centre’s finances). A similar situation pertained at the Fluids Centre in 2007, where Prof. Fluids had achieved permanent positions for his two seniors as researchers, where they were in effect locked into (and funded through) the research mission activities of the Centre.

The converse can also be illustrated with reference, for example, to the actual situation of seniors in a Model C (virtual) centre type – where, importantly, all the professors in this network structure actually held tenured positions within departments as
traditional researcher-lecturers. For example, in the Centre-as-Agglomeration which called itself a centre but which I analysed as a network or agglomeration of professors, it was observed how each professor essentially controlled her/his own funding and own research direction, and might even ‘reverse out’ of this Centre and form an autonomous small Model B-type unit if s/he so desired. In fact, a careful examination of all such virtual centres (Cases 3, 8, 9, 10) demonstrated such potential autonomy to withdraw because of their appointment as tenured lecturers within a department.5

The general point here is clear: in the Model A type of organisation, there is a research direction or specific niche around which all the senior researchers are obligated to organise their research subgroups, as part of the research contract positions they hold and which are linked to the overall research mission of the centre. This has important functionalities for clients or external stakeholder/partners, as explored in the next point.

The second important point – of functionality for clients in terms of continuity and predictability – arises from precisely this ‘lock-in’ of senior researchers to the Model A centre mission. It relates to the ability of such a centre to provide continuity and predictability of research mission and research outputs over time. The question therefore arises as to whether those who need use-oriented research (UIBR and/or PAR) – especially stakeholders in industry, government or civil society – should be able to expect that the research direction and specific niche area of a centre remain constant and predictable over time (say at least one or two decades).

Much evidence from the 10 application-oriented cases suggests that the answer to this questions is ‘yes, definitely’. For example, when the leader of the virtual Centre-as-Department (Case 8) left the Western Cape after 2000, the overall research niche established by this director-HoD became fragmented, and by 2007 each academic in the department was pursuing research in her/his own separate small unit. Some industry funding was withdrawn when the director departed – in part because the industry partners felt that the overall research direction of this (virtual) centre had been lost. Similarly, my analysis of the virtual Centre-as-Agglomeration (Case 10) – with each professor controlling substantial own funding in her/his own small unit or subgroup – revealed a continual internal debate about the absence of a strong ‘collective mission’ of research and the resulting problems in obtaining long-term industry commitment.

This general issue was succinctly captured in a thoughtful comment by the director of the Agriculture Centre in 2000, cited in my analysis of this Model A centre type:

Because there are the growth objectives [linked to the Agri-Sector Industry Network’s own 20-year plan for growth in this sector], although your [Agriculture Centre research] project is assessed on a yearly basis, the priority doesn’t change. If they [the industry network] have identified say, for instance, the development of new yeast strains that will reduce the levels of sulphur dioxide in [a product] as a priority, they commit themselves to
that priority. If the [research] project runs through five years, or even ten years, the priority will not change…

The general point of this evidence is thus clear: if one wishes to work over a lengthy period with clients (from industry, government or civil society) to produce certain forms of high-quality UIBR and/or PAR outputs in a specific niche area, it is advantageous to construct a research grouping with researchers clearly locked in to a long-term research mission. Model A facilitates this with appointments of researchers to (relatively) permanent positions within the centre, with subgroups held together by a director and (usually) a centre governing board.

There is a third important point that needs to be stressed about the functionality of a Model A centre type: the effectiveness of size. A critical mass of preferably four or more subgroups under seniors not only provides functionality with respect to continuity and predictability, but also enables much needed larger research projects to be undertaken for stakeholders.

It should also be recalled from the earlier analysis (in Chapter 2) of the combined U–I–G research efforts in the USA during the Second World War, that it became obvious even to the academics involved that a set of larger and collective research programmes needed to be constructed if the war aims were to be achieved. Each of these sets of war mission-directed programmes was in effect undertaken by larger research groups – de facto centres, or even groups or clusters of centres – led by research directors. Of course, this is not to argue that our Western Cape universities need to go on a ‘war footing’ for their research activities. I am instead suggesting that if the work of UIBR and PAR at our universities is to achieve – over the medium to long term – the forms of research output urgently needed by clients in the knowledge society (in relation to poverty alleviation, manufacturing exports, environmentally sustainable industry, and so on), we cannot avoid the systematic development at each HEI of at least some carefully selected, larger research centres with a Model A-type organisation.

This means that some South African university professors will probably need to give up part of the unrestrained research control they hold in smaller units such as the traditional virtual Science Unit (Case 0) or the new real Genes Unit (Case 2). In this they would be like the professors in the USA during the Second World War, when embryonic second academic transformation research centre-type structures began to emerge. They would also be like many American and international professors who, especially since the 1980s, have become involved in larger and better funded research centres and even networks of centres as part of a globally expanding second academic transformation. But the gain achieved by giving up some of the academic freedom involved in directing one’s own research activity in a smaller unit, or even in a loose network of professors of a virtual centre, is – one hopes – more sustainable and more long-term research, in a common and more extensive research programme of UIBR and PAR for the knowledge society.

There is a final, fourth point to stress about such research centres: their functionality in performing postgraduate teaching and professional training functions – both
on and off campus. It was observed from the case study data that various larger centres were particularly efficient in producing high-quality master’s programmes and PhD training in their HEIs, as well as in running excellent professional training courses for clients from I-G-CS. For example, in 2000 the Agriculture Centre, with its director and four or five senior researchers, had a focused, interdisciplinary postgraduate programme on biotechnology linked to its agri-sector research niche, with an enrolment of about 70 honours, master’s and PhD students. The fact that such a critical mass (5+) of senior researchers could concentrate most of its teaching at postgraduate level in this niche area was definitely an advantage. Similarly, the interdepartmental network of professors (10+) of the Centre-as-Agglomeration had, from its inception in the early 1980s until 2007, run a high-quality coursework-cum-thesis master’s programme focused on its specific research niche, in addition to graduating many PhDs over this period. Other research centre-type groupings also developed training programmes and workshops for professionals, especially in industry or government. The most dynamic of all the cases was probably the Sustainability Centre (Model A type): it ran not only annual, highly valued training programmes for professionals from industry and government, but also workshops for community bodies and NGOs each year.

In summary, the central argument related to all the above points is that our universities and UoTs, and most importantly the ‘traditional’ academics in them, need to learn to value the larger, new Model A centre-type organisation. These new real centres have a critical mass of senior researchers, as well as clearly defined research niches and missions combining UIBR and PAR. They are often associated with dedicated postgraduate teaching programmes, possibly complemented by some professional training courses for a range of clients, and – importantly – they might be located either (preferably) alongside or (sometimes) in academic departments. Some theoretical and policy implications associated with these ideas will be examined further in the concluding chapter.

Some strengths of a smaller Model B unit type

The preceding discussion stressed the need to value and build new, larger centres of Model A type in our HEIs. At the same time, one of the more unexpected findings of this study needs to be confronted honestly. A number of the cases which initially seemed to be developing towards a fairly stable centre-type organisation had become diffused or even fragmented by 2005 or 2007, with individual professors falling back into the mode of organisation of a smaller Model B type to continue their UIBR and PAR work.

As already noted, such a return to smaller units was observed after 2005 for both the (virtual) Centre-as-Department and the Centre-in-a-Faculty. My analyses of Case 10 (the Centre-as-Agglomeration) and Case 6 (the Sustainability Centre) likewise suggested that they might, under certain conditions, begin to consolidate their research around a smaller Model B-type organisation, for various reasons relating to changes in funding and personnel configurations.
It is therefore difficult not to draw the conclusion that it often seems rational, especially in the current HEI context of weaker funding and weaker visions of larger centre-type organisation, for senior academics to revert to working in smaller Model B-type research groupings.

There seems to me to be at least four main reasons for this, some linked directly to major issues of inadequate funding and vision. Firstly, there are the effects of the history and culture of the ‘traditional’ Model T-type basic research-oriented grouping, which is still firmly rooted in our universities and is based on a solid system of historical, departmentally based academic rules, norms, values and associated power networks which have their origins in the international first academic transformation of the 1800s. For many academics it therefore appears rational to undertake research – whether or not it is use-oriented – in this way. The second reason is that many university academics and administrators do not support or understand the building of larger, new Model A-type centres with an orientation towards the third university mission of socio-economic–cultural development. The third reason is the underfunding by government of research in our universities, which may discourage innovative academics who then fall back into whatever works in a complex and difficult situation. A fourth reason is that it is often difficult to achieve good research cooperation or social glue among a group of seniors. For example, in the Agriculture Centre the senior researchers ‘reversed’ into an academic department after their mentor-director (who had also supervised their PhDs) departed – partly because they worried about the impact of an outsider entering as new director. Similarly, an absence of academic glue among some of the networks of professors (e.g. in Cases 8 and 9) contributed to some of the fragmentation into smaller units by 2007. In other words, numerous senior researchers find it easier, and also more productive, to work independently in their own small research groups, rather than take on some of the obvious benefits (in funding and other resources) gained by joining larger centres and networks.

Researchers and academics in larger groupings may nonetheless continue with valuable UIBR and PAR – as numerous examples above have shown – until, to coin a phrase, ‘things fall apart’ in their larger research centres or networks. They often then seek to fall back on a smaller unit type of research organisation. It is important, however, to acknowledge that when a professor chooses to work only in a small Model B-type structure, or to fall back on such a unit because other structures are weak, her/his use-oriented research work – both UIBR and PAR – can certainly be at a high level, in terms of both quantity and quality. This was clearly the case with Prof. Genes, and also with Prof. Biogenetics, both innovative and highly productive researchers, who for numerous years produced excellent UIBR (and some PAR) by choosing to work in a Model B-type grouping. Like them, many other researchers at our HEIs choose not to join or build larger structures.

A conclusion that I draw from the preceding arguments is that, while it is vital to build new, larger research centres across our universities in the future, it is also possible for them to achieve substantial results from UIBR and PAR by undertaking
research work in smaller Model B-type units. In certain contexts such smaller units – especially given the resistance of many professors to loss of research autonomy – are actually very productive. It is thus viable, and constructive, for university research leaders and managers to encourage the parallel development of both Model A- and Model B-type organisations in pursuit of a third mission. This also applies, I argue below, to Model C-type structures.

The viability of a Model C virtual centre type

As described in the Introduction to Part 1, the data from the second phase of interviews at the Space (Virtual) Centre suggested the viability and relative stability of a new model type in relation to use-oriented research.

This was reinforced by data emerging from three other groupings structured around such a network or cluster of professors (Cases 8, 9 and 10), described respectively as a Centre-as-Department, a Centre-in-a-Faculty and a Centre-as-Agglomeration. While each of these three groupings was observed to have experienced problems of internal organisation in both 2005 and 2007, the relative viability and functionality of a professor linked in a research cluster or network to other professors continued to emerge from the interviews and from other international data collected.

By the end of the third phase of interviews a conclusion emerged about the role of research networks of professors. This was that in many ways, the Model C type of research grouping could also be extremely innovative and productive for both UIBR and PAR. For this to happen, our university leaders and managers, including deans and HoDs, need to understand that this internal structure or mode of organisation is neither like the Model A-type Agriculture Centre nor like the Model B-type Genes Unit, but operates as another important and functional type altogether.

This functionality seems essentially to derive from the fact that the Model C type combines some of the advantages of both Model A and Model B types. On the one hand, the larger network of professors provides a critical mass of researchers and even a certain direction and continuity of 'collective mission' (albeit less strongly than for the Model A type) – which is advantageous for external stakeholders linked to the third mission. The network of professors may also provide the basis for collective organisation of coursework postgraduate programmes, joint supervision of theses, and the development of professional training courses – all based in the research niche area of the network – as was observed for almost all the virtual centre cases examined in Part 2. On the other hand, some of the autonomy for a professor-PI to control the direction and funding of her/his own research (as vested in the Model B type) is retained by each professor of such a network. In some ways, therefore, such a Model C internal organisational structure can be viewed as a compromise between the forces of Model A and those of Model B.

It seems clear from the trend analysis of data for 2000–2005–2007 for the virtual centre cases that, at least under current conditions at South African universities and UoTs, the Model C type is performing valuable UIBR and PAR for a range of
important clients in industry, government and civil society. Similarly, it was observed in Chapter 3 that in the EU, NoEs of researchers across countries in Europe, in relation to the FPs of the past decade, were very important building blocks for the allocation of research funding for these programmes.

It is therefore important that university leaders and managers do not undermine such network structures through hasty or poorly conceived new schemes for research development. This different Model C should, I argue, be encouraged and enhanced in our country’s HEIs, alongside the parallel development in particular of new Model A-type centres.

Where best to be: In a department or a faculty/school?

Thus far in my discussion of the model types, the issue has been left open as to whether a use-oriented centre or unit or virtual centre would be better located in an academic department, or in a faculty/school, or even perhaps left ‘floating’ in the university, unattached to any specific faculty or school. In fact, in some current university discourses in South Africa (and internationally) it is often assumed that centre-type structures should be located outside a department. This is because they are usually assumed to be interdisciplinary, which is not necessarily true, while small units are often assumed to be located inside specific departments. Certainly, when this study began in 2000, I was somewhat influenced by such discourses. Yet the data indicated otherwise. I would therefore now suggest that there are no clear pointers, given the varied evidence of some Western Cape centres functioning very well in departments, while others were doing equally well outside departments (examples of these were the Fluids Centre, located in a department, and the Agriculture Centre, located outside a department in 2000). Similarly, those working in some of the small Model B-type units seemed happy to be outside a department (such as Prof. Genes), while others (for instance, Prof. Biogenetics) could not conceive of themselves except as located firmly in their department-cum-discipline. Moreover, as was pointed out earlier, by the definition applied here to the construct of a Model A centre type, it might be located formally in a department as long as the centre maintained clear autonomy over its research mission and finances (as did both the Fluids Centre and the Sustainability Centre).

The question ‘Where best to be?’ can therefore best be answered, I propose, by saying that the answer depends on the context, and that one needs to weigh up the pros and cons carefully in each specific situation. The director of the Agriculture Centre in 2000 listed the following pros for why it was best for his Centre to be located outside an allied agricultural department, but nonetheless with links to it:

- Being a centre outside a department can facilitate one’s mission as an interdisciplinary or transdisciplinary research group.
- Being outside a department, and being ‘advertised’ clearly as outside any one discipline, enables a centre to recruit postgraduates from more than one department, from across faculties, and even from other universities.
• Funders, especially industry, might often be more positive towards a research grouping that is not historically tied to only one department, with its relatively narrow structures and presumed internal politics.

• More generally, ‘Having a separate structure, you don’t threaten anybody [in the department]…[this centre] was a new structure and you could start fresh’ (cited in Case 1).

Essentially, therefore, in terms of earlier arguments about the new third mission and second academic transformation, it can be hypothesised that a centre outside a department – though having to face broader faculty and university rules, norms and politics – is likely to be relatively independent of traditional departmental rules and values, of systems of the first academic transformation, and of various inter- and intra-departmental battles. All these departmental elements can strangle and suffocate the newly emerging centres of the second transformation. So perhaps it is often better for a new real centre to be organisationally separate (to stand alone) – not only in terms of control over research mission and finances, but even in actual physical location – from an academic department. Interestingly, all the above reasons for standing alone strongly influenced Prof. Genes in his decision to be entirely separate, also physically, from any department in his science faculty (see Case 2).

Conversely, after considering the location of the Space (Virtual) Centre in an engineering department, there do appear to be some important advantages to having a research centre (or unit) and its senior researchers in an academic department (as also evidenced by the Fluids Centre and the Sustainability Centre). Among these are the following:

• A department rooted in a clear field of scholarship (often termed a discipline) provides an intellectual taproot from which a research grouping (centre or unit) can gain important nourishment in terms of scholarly research.

• The research grouping is able to use the technical infrastructure of the department (equipment, computer facilities, even some administrative infrastructure).

• Professors and other researchers with tenure have their salaries borne by the academic department (via the university). In addition, departmental bursaries for postgraduates may be available, which can help significantly in the funding of student labour for the research enterprise.

• If some of the professors and other researchers leave the research group, other senior members in the department may be able to step in or join the research being conducted by the subgroups of the departmentally based laboratory, thus providing vital continuity of research (and postgraduate supervision). This is also a form of continuity highly valued by outside clients.

• More generally, a department provides a vital protective shell of financial, administrative and, as importantly, academic support, as well as high levels of collegiality. These all help to cement a research centre in a department, and to buttress it from difficult university and outside forces that were seen to have an impact on all 11 cases.
In summary, therefore, the above evidence suggests that the major advantages of the departmental umbrella lie in various forms of protection (financial, material, cultural, and the like), as well as scholarly nourishment, provided by location inside a department. Conversely, a major advantage of having a centre (and even a small unit) located outside a department lies in the various forms of freedom it allows to pursue research activities, unrestrained by departmental interests and dynamics. Even here, though, it is often useful, as the director of the Agriculture Centre understood in 2000, to have indirect links with at least one allied department. There thus seems to be a complex set of pros and cons, which all need to be carefully weighed up in the specific context of each case in each HEI.

Are U–I research linkages fundamentally different from U–CS linkages?

Having examined the way in which external research linkages were developed by the 10 use-oriented groupings, we need to consider whether the characteristics of U–I linkages appear to be fundamentally different from those of U–CS linkages.

In terms of empirical trends, the initial answer to this question appears to be a strong ‘yes’. As noted, the Sustainability Centre was the only case that had developed strong links with civil society, namely with local Western Cape communities, NGOs and some local government bodies, all affected in one way or another by issues of sustainability. This centre was observed, at the same time, to have undertaken research (and education) work for industry and national government bodies as well, in other words, it was inserted significantly into triple helix relations. Nevertheless, the mission of this grouping, perhaps in part because of its particular research niche, was always oriented also towards building U–CS or what I have termed ‘fourth helix’ relations. In this case study, its co-director put it this way:

> You know, that’s perhaps where we [in the Sustainability Centre] are slightly different from, maybe, mainstream academic departments [in] that we’re trying to be more practical, more relevant, and to produce materials that are also of value to the broader community… (cited in Case 6)

Only two other groupings, the Agriculture Centre and the Space Centre, were observed to have developed some, albeit relatively minor, linkages with organisations outside mainstream industry (involving some small farmer groups in the case of the former, and some space science projects for schools in the case of the latter). In fact, for all the others, no U–CS linkages were observed during the investigations across the period 2000–07. This was despite the fact that, as suggested previously, even though most of the 10 cases had their research niches in engineering–science fields – where U–I linkages have been historically strong – for almost all 10 there were observed to be opportunities to build U–CS linkages if the groupings had so desired. The empirical evidence here therefore points clearly to the relative ‘orphan’ status of linkages with the broader civil society.

Yet in theoretical terms I argued in Chapter 3 that what I called ‘civic engaged scholarship’ – scholarly work embedded in U–CS relations – does (and should)
incorporate the same criteria and standards as those for U–I research relations. For example, such civic research engagement includes what Boyer (1990) has called the scholarships of ‘application’ and ‘integration’, and should be bound by standards of excellence (why would civic groups want sloppy research?). My argument included the proposal that this fourth helix should wherever possible incorporate civil society collaboration and even knowledge contributions from civil society bodies – but this applies equally to U–I relations (as observed for various cases in Part 2). So there seems to be a disjuncture between what seems ‘obvious’ theoretically – a similarity between the ideal types of U–CS and U–I research relations – and what was found empirically to be a sharp dominance of industry.

Despite the undoubted socio-economic force of industry – what might almost be called a ‘social movement of industrial companies’ linked to the emergent third capitalist industrial revolution – impacting on Western Cape (and international) research groupings, I would still like to argue that national systems of innovation require ‘innovation’ – or the development of novel research outputs – for civil society just as much as for industry. I would argue further that just as Model A centre types (and also Model C virtual centre types) achieve what I have called ‘efficiency functionalities’ in their research performance for external stakeholders like industry, so these university research types are equally needed by civil society bodies for their own development needs. Thus I hypothesise that the advantages noted above of such centre types – in terms of i) lock-in to a directed mission of use-oriented research; ii) continuity and predictability; iii) critical mass of senior researchers; and iv) capacity for professional training courses – all apply equally to U–CS linkages. Civil society bodies such as trade unions, community organisations and local municipal organisations, in order to deal with critical issues of housing, transport, urban renewal and so on, need exactly such ‘functionalities’ from university-based centres and units, if the latter are to accomplish their third mission effectively in relation to civil society organisations.

My point is therefore that there is clearly an empirical dominance of U–I relations, but this does not have to be so. At the same time, if the argument is accepted of theoretical equivalence between U–I and U–CS linkages with regard to modes and structures of engaged scholarship by university researchers, there is a need to consider in more depth why – empirically – there is such a skewed emphasis towards U–I relations (internationally, and in the Western Cape). The next section of this chapter examines evidence of important factors that enhance and inhibit use-oriented research for external stakeholders or clients.

Factors enhancing and inhibiting use-oriented research: Findings from the case studies

It was proposed in the first section of this chapter that in many ways the 10 use-oriented cases can be fruitfully viewed as reflecting a combination of ‘chaos and creativity’. To put it another way, these cases are impacted on by the forces of both
the older first and the new second academic transformations; this results in a series of what were termed 'micro-contradictions', whereby inhibiting and enhancing factors continually influence their research, simultaneously facilitating and blocking the unlocking of their knowledge for the broader society. This section seeks to explore further a set of specific factors that, from the analysis of the individual cases in Part 2, appear to be significant sources of such micro-contradictions across many and sometimes all the cases. The factors discussed below include challenges within the research groupings: of research funding, of career track for senior researchers, of adequate support for post-docs and postgraduates, of leadership and research culture, and finally of synergies between basic/fundamental and more use-oriented forms of research.

Funding is fundamental

From the findings of the Western Cape use-oriented case studies, it is difficult to exaggerate how fundamental the funding problem is for these research centres and units at our universities and UoTs. There was hardly a case in which, during each of the three phases of interviews, there were no expressions of anxiety about medium-to long-term funding. As the director of the Sustainability Centre (Case 6) put it in his 2000 interview about the Centre's funding struggle ever since the 1980s: 'But the unit has to cover all its own costs. So right from the word go it has never not had to focus on its own costs.'

Even worse – as was observed in the analysis of this Centre affiliated to a department – many of the senior contract researchers were teaching and supervising students for the departmental master's programme, which meant that the research grouping was in effect subsidising the university, rather than the other way around. And this was by no means the only case in such a situation: our universities have been so steeped in first academic transformation norms and values that, until very recently, most have never sought to calculate adequately the full 'costs to the university' of one hour of teaching master's students or intensive thesis supervision (especially for PhD students). When senior contract researchers from research units and centres undertake this work for departments, the savings achieved because tenured academics are not doing this work is often never properly confronted.

In the case of the Sustainability Centre, it was noted further that its long-term funding squeeze was almost certainly the most crucial factor that had caused its senior contract researcher to leave around 2005 and its co-director to take up a tenured position in the academic department around 2007.

Another good example, which early on in the study made me take a closer look at the case study data about funding, was the Agriculture Centre, the exemplar of a Model A 'new real centre'. In 2000 the Centre seemed to be well resourced as it was funded (over 90 per cent) by its Agri-Sector Industry Network. This seemed to be a unique and extremely well-organised industry funding structure – to the tune of over R5 million per annum, which included most researcher salaries and postgraduate bursaries and
was derived primarily from a self-imposed levy by the agri-sector. In some ways this might even be regarded as an agri-sector ‘research equivalent’ of the Sector Education and Training Authorities (SETAs) introduced after 2000 for over 20 industrial sectors of the country by means of a national, government-driven 1 per cent levy on medium to large industrial organisations to facilitate education and training.

Yet this R5 million was still not enough for the Agriculture Centre to function properly in 2000. As was seen from the interview data, the director at that time had been falling back on invested reserves in order to pay the researchers’ salaries and other expenses needed to achieve their research goals. When he departed soon after 2000 the Agriculture Centre ‘reversed’ and joined its allied academic department, with most researcher salaries now borne by the department (via the university). This was not least because the Industry Network itself believed that the university and other funders needed to step in with support, especially for the UIBR side of the work, which this agri-sector industry felt it could not carry alone.

It thus seems clear that even the relatively highly resourced Agriculture Centre of 2000 was simply not finding the funding it needed as a Model A centre. Overall, none of the research groupings in the study appeared to have adequate levels of funding for achieving their research missions, including also Case 0, whose curiosity-oriented Prof. Science also spoke of serious problems in funding his basic research work.

Admittedly, there have been serious initiatives after 2000 to improve the situation of university research funding in South Africa. For example, it was noted in the Introduction to Part 2 how industry–university-linked THRIP funding supported by the Department of Trade and Industry has been consolidated and improved; how after 2001 the new BRICs with DST funding began to impact on biotechnology areas (including on the Agriculture Centre after 2004); and how the research chair initiative of the NRF and DST introduced in 2006 aims to create over 200 such chairs across the country.

So it might nevertheless be possible to believe that research funding at our HEIs is more or less on track, or at least much more on track than it was in the 1990s. In fact, many observers believe – and a superficial cut through the case study data of Part 2 suggests – that researchers in both smaller units and larger centres do always seem to manage to acquire some sort of funding.

However, I would argue that a close look at the in-depth stories of interviewees across the cases in Part 2 suggests the converse: that there are very serious problems indeed at our HEIs about research funding, especially for UIBR but also for PAR and PBR.

These arguments based on my Western Cape case studies can be supported by some of the quantitative R&D expenditure data for South Africa outlined in the Introduction to Part 2. Here it was observed that while the ratio of South African GERD to GDP had increased steadily since the 1990s to reach 0.95 by 2006 (similar
to ‘medium–low’ countries like Brazil and Turkey), this was considerably below the ‘high’ countries which have ratios of 2.0+. Moreover, while these data have been debated nationally over the past decade, there has been relatively little debate about the fact that the South African figure for basic research is around 0.2 per cent of GDP, while for the USA and Sweden it is around 0.5 per cent. This suggests that we lack a national debate or understanding about the need to fund basic research in relation to its impact on UIBR (and even PAR).

As importantly, significant new data (of 2005) that were also highlighted in the Introduction to Part 2 indicated that our business expenditure (BERD) as a percentage of GERD (58 per cent) was up among medium–high countries such as the UK and the Netherlands, that is, much higher than medium–low countries like Brazil and Turkey (with around 40 per cent). Moreover, it was shown that while the percentage of higher education R&D derived from business was well below 10 per cent for North American countries (e.g. USA 5 per cent) and most countries of the EU (e.g. Sweden 5.2 per cent), for South Africa it was 11.6 per cent – with only South Korea (15.2 per cent) and Turkey (22.7 per cent) standing above us in Table ii.2. This sharply highlights the relative ‘over-funding’ of our university research by business/industry (and also by foreign funding sources, which amounted to 11.2 per cent), compared to national government funding. It therefore points clearly to a relatively lower support level for university research funding from South African state agencies, compared especially to the governments of advanced industrial countries, whose universities are leading the second academic transformation.

Another, more qualitative, approach to the argument is to compare the funding difficulties of the Agriculture Centre with the funding levels around 2005 for the new South African CoEs and research chairs. The Introduction to Part 2 pointed out that NRF CoEs were funded at that time at a level of around R5 million of core funding per annum, while the new research chairs initiated in 2006 had a level of funding of R2.5 million each. Yet all the evidence for the Agriculture Centre suggests that for a centre like this, with a director and three or four senior researchers leading subgroups – or even for a network type of centre (like Case 3, with three or four subgroups of professors) – the R5 million level is simply much too low. I would go even further and suggest that on its own this level of funding is a recipe for the fragmentation of centre types into smaller units of Model B type (or for a reverse into a department, as occurred with the Agriculture Centre in 2005).

The central point here is that current levels of research funding at our universities, particularly for the building of high-quality UIBR centres of research along the lines of Model A, are hopelessly inadequate. Some national research policy initiatives have perhaps even been somewhat misconceived in under-stressing this (more basic) side of the research spectrum. These issues will be pursued in the final chapter of the book. Here it is important to turn to a major question that is directly linked to the ‘funding is fundamental’ issue: how to retain senior researchers in our new and dynamic use-oriented research centres?
Employment of senior researchers is also fundamental

In the analysis of the Centre-in-a-Faculty (Case 9), one major impediment was the recruitment and retention of senior researchers. In the 2000 interview the UoT dean of engineering said: ‘For me, being able to get qualified, competent and enthusiastic staff with initiative and vision is what I would like…If all my research projects could have good people, it would be great.’

In the Introduction to Part 2, an overview of our national situation regarding research personnel showed no growth at all of researcher FTEs in the higher education sector between 1992 and 2005, and even a fall in the government sector (see Table ii.4). International comparisons (Figure ii.1) showed South Africa well below even ‘middle-range’ countries like Argentina, Greece and Turkey in the proportion of FTE researchers per 1 000 total employment.

So at the national level the situation is problematic indeed. At a more micro level, extensive evidence has been provided across the case studies of Part 2 of the resignations of numerous vital senior researchers. This was partly because of inadequate salaries but, as importantly in the case of every research grouping studied, because research officer posts were usually contract jobs. Contract positions offer no clear career prospects for their incumbents – even when, like the co-director of the Sustainability Centre, they have held such positions for over 20 years (which was why, as observed, this researcher eventually took up a tenured associate professor position in the allied department in 2007).

The case studies provided many examples of the crucial value of the layer of senior researchers above the post-docs. Nonetheless, these types of researchers frequently depart, leaving holes within their research groupings that are very difficult to fill. The evidence from the case studies suggests that no Band-Aid fix is going to make any significant difference to this dire situation, rooted in a clash of second academic transformation values and systems with the older traditional structures and practices. I shall instead propose that radically different and far-reaching schemes are needed for South African universities, linked to the new third mission, to provide our larger centres and even some smaller units with the layer of senior researchers they desperately need in order to conduct the UIBR and PAR currently sought from them by a range of industry, government and civil society clients.

Figure 6.2 A new national researcher career track

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<td>Researcher-lecturer:</td>
<td>Researcher:</td>
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<tr>
<td>• Professor</td>
<td>• Professor-researcher</td>
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<tr>
<td>• Associate professor</td>
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<td>• Senior lecturer</td>
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<td>• Lecturer</td>
<td>• Researcher (post-doc)</td>
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The main proposals for confronting the issues involved in staffing a layer of senior researchers are put forward as follows, with reference to Figure 6.2.9

Firstly, to address the expansion of UIBR and PAR linked to the second academic transformation, our universities have to consider the idea of establishing a new career track for what might be termed ‘research fellows’ or ‘professor/associate professor-researchers’.10 Such researchers have never officially been part of our university systems, since their employment has been based on first academic transformation norms and rules that make provision for a layer of contract researchers as ‘assistants’ to professors (as discussed in Chapter 3, especially with reference to German professor-chairs and their untenured assistants since the 1800s). However, such senior researchers, often located in a research centre or unit, are part of the new and expanding third university mission of today and should be provided with tenure or at least long-term contracts (for a minimum of five years). Alongside their primary role of research, their teaching duties should be mainly at postgraduate level and they should be given full recognition as genuine ‘scholars’,11 with voting and other rights on departmental and faculty boards and university committees, where relevant.

There should be no doubt that such a change would involve a revolution of values and systems at our universities. South African universities have hardly begun to recognise the scale of the second academic transformation taking place internationally, and the tenured ‘traditional’ professors, acting as ‘researcher-lecturers’, have been kings in this country’s universities for a century. (Internationally this has been true for two centuries – effectively since the first academic transformation began in Germany.) My proposal would also lead to substantial changes in the identity structure of academic positions. The accepted notion of a Model T-type professor researcher-lecturer leading a unit would no longer be seen as the only possible, or the main, modality for a research grouping. The spectrum would have to be extended to enable some academics to have a primary identity as researchers, while others might take on a primary identity as lecturers. It is worth noting that in 2007 the Fluids Centre (Case 7) was the only case to have fully embraced this type of permanent researcher career track for two of its senior researchers, under its dynamic research director. It is hoped that the idea of creating a new researcher career track will be pursued much more widely across our universities and UoTs in the near future.

My second proposal relates to financial issues linked to the proposed researcher career track. Since the cost of academic staff currently comprises well over half the total annual expenditure of each HEI in South Africa, such a substantial new career track would have high cost implications. The existing formulae for higher education funding are based primarily on a subsidy system rooted in student enrolments (and to a lesser extent on student graduates or throughputs). Essentially, what occurs is that large undergraduate classes are in effect cross-subsidising postgraduate studies and research (including the time professors spend on thesis supervision and research work). The whole philosophical underpinning of these subsidy formulae therefore needs debate and reconsideration in the medium term. However, the current subsidy formulae do include funding for university research
activities and outputs (including postgraduate theses) and these could be revised in the short term. This would imply, among other things, that existing subsidies for peer-reviewed publications of academics and researchers, as well as for master’s and doctoral (thesis) student throughputs and outputs (including their publications), could be increased immediately from their current levels. Along with this, over the longer term, different forms of UIBR and PAR outputs – such as policy work and evaluation studies and, again, their resulting reports and even workshops for clients – would all have to be considered with regard to direct and/or indirect forms of subsidy by the Department of Higher Education and Training (or the DST). In other words, the current higher education research subsidy system as a whole would need substantial rethinking in the short, medium and long term.

My third proposal concerns the need for a significant rise in higher education research funding from government relative to funding received from industry, which, as illustrated above, carries a considerably larger proportion of direct research funding for our universities than is the norm for OECD countries. Admittedly, any such proposal for increased government subsidisation of higher education research needs to compete with demands from the South African population for health, housing, transport, infrastructure, and so on. It is unrealistic to expect the government to fund enormous increases in university research subsidies in competition with other demands from the mass of poor people in our country. But at the same time a national position needs to be articulated by our HEIs – much more clearly than at present – that in the ‘knowledge society’ of the third industrial revolution issues of health, housing, transport, etc. are not independent of university research efforts. In fact, university research, linked to the second academic transformation and third mission, should directly seek to provide knowledge for the alleviation of such social problems and hence for the condition of poverty of the majority of our population.

In terms of these arguments, any serious attempt to enhance UIBR and PAR at our HEIs would require, as a minimum, a significantly higher level of research subsidy led by the government. One suggestion, in addition to the points just made about changes in university subsidy formulae, is a form of subsidy indirectly derived from a national, government-coordinated industry levy. The example of the Agri-Sector Industry Network linked to the Agriculture Centre provides a valuable insight into a possible way forward. This agri-sector was imposing a levy on its own industry in order to fund research activities in a wide range of university and non-university research groupings. The aim of the levy was to fulfil the agri-sector industry’s needs, particularly in terms of UIBR and PAR. My proposal is therefore that many more sectors of industry (for example, mining, the motor industry and fishing), under a government-led initiative parallel to the SETAs, need to consider developing ‘industry networks of expertise and technology’ similar to the Industry Network for research funding observed in Case 1.

In summary, my essential argument here is that, if one accepts that the employment of a new layer of senior researchers is fundamental to our university-based research centres and units, then at least the following proposals need to be seriously considered:
• A new career track should be created for senior researchers, supported by massive new national research funding initiatives.
• This should be done by means, firstly, of revising and expanding the existing government subsidy formulae for research activities (including UIBR and PAR) at our universities and UoTs.
• It should also be done through the development, for example, of many more industry sector-organised (but government-coordinated) research funding structures, along the lines of what was observed in the Agriculture Centre in 2000.

Specifying the research roles of post-docs, and master’s and PhD students

The ‘post-doc layer’ within a research grouping, as illustrated in numerous case studies in Part 2, is an extremely valuable one. Prof. Biogenetics of Case 6 noted: ‘I do spend a lot of my time supervising students [postgraduates in the lab] but one step away. He [a post-doc] does the day-to-day. I do the bigger picture and the management.’

In fact, compared to Europe and North America the utilisation of post-doc students in research groupings at our universities is very underdeveloped. The reader may recall that the traditional Prof. Science had none in his small research group (Case 0), and in 2000 suggested some reasons for this underdevelopment. He was quoted as saying: ‘[T]he size of [basic research] grants is generally so small that hiring a post-doc would use up 90 per cent or all of it, leaving nothing left over.’ He also argued that, just as it had been historically more rational for some white PhDs, it was currently more rational for black PhDs, on gaining a doctorate, to take up an academic post – such as lecturer or senior lecturer, if seeking a university career – instead of staying on to work as a post-doc.

If the career track proposed above for more senior researchers – with tenure or long-term contracts – were to become established at our HEIs, the bottom level of this track would be for those who had just attained a doctorate. This would be preferable to the current low levels of remuneration obtained by post-docs nationally.\(^1^2\) It might also be especially suitable for PhD graduates who wish to pursue mainly research, rather than teaching, as a university career path. This preference was suggested by quite a number of the less senior researchers interviewed for this study, for example the post-doc researcher in the Centre-as-Agglomeration (Case 10), who had recently taken up a position as a consultant: ‘There wasn’t really a future for me as a senior research officer at [name of centre]…I was not really interested [in a lecturing post], so I took the chance to [leave the centre and] work full time [as an industrial research consultant].’

It can thus be argued that the best way for our universities to develop a larger layer of post-docs would be to ensure that there is a career track for long-term researchers, who might begin at the post-doc level as research officers (Figure 6.2), and who see their medium-term future as moving up into more senior research positions.

But this points to another layer, which in South Africa is currently viewed as the lowest level of researcher: master’s students. It is important to consider this lowest
level, too, since we frequently found during the Western Cape interviews that students undertaking their master’s theses were being asked to do work which, in European or North American universities, would only be asked of PhDs or often even post-docs. This links to a pervasive ideology at some of our universities that master’s students ‘should be doing substantial research’, a notion that is reinforced by the current higher education subsidy formula, which includes master’s theses (and master’s minor dissertations) as eligible for a significant research subsidy component. Nonetheless, whatever one’s view about whether or not a master’s thesis should embody ‘real research’, the essential point is that many of our research centres and units rely far too much on master’s student labour for research activities, which often require higher levels of research expertise than their training has provided.

For example, in the Sustainability Centre (Case 6) during the period from 2000 to 2007, only the co-director and director held PhDs; all the other contract researchers (about 10 at any one time) had at most a master’s qualification. These relatively junior researchers were among the most energetic and committed encountered across the 11 case studies, but they often had to undertake research consultancies for clients involving quite complex work. The analysis of Case 6 suggested that this had resulted in less UIBR being undertaken than could have been, if more senior-level researchers had been drawn into such an innovative research centre. The overall situation was well captured by one researcher (with a master’s degree), who eventually departed to begin his own consultancy business, but who spoke sadly in his interview of the PhD he had never completed while working in the Sustainability Centre:

...But, you know, the model’s not there [for paid time off to write up PhDs]...our salaries weren’t being paid by the university, they were being paid by ourselves [from contract research funding, which did not have a built-in component for the PhD-based work].

In contrast, when three core researchers in the Fluids Centre (Case 7) attained their PhDs by 2005 under the strong mentorship of its director, this greatly facilitated the transformation of this research grouping from ‘small unit to larger centre’. As the director put it during the 2007 interview: ‘They got their PhDs. So it changed from their being pushed to them pushing...’

Conversely, it was observed at the Space (Virtual) Centre (Case 3) that four to six departmental professors were able to give direct academic leadership to about 25 postgraduates at any one time in the Space Lab. Yet fewer than 15 per cent of these postgraduates were PhD students, with most of them completing master’s engineering theses based on research work done in developing the microsatellite. It was noted that this master’s-level student labour formed a basis that made the project feasible (student input up to the 1999 launch was calculated to have been 150 student-years). It seemed to achieve a relatively successful research mix and division of labour between the master’s and PhD work on the one hand, and a degree of more UIBR by the professors on the other. However, after 2005 the relative proportion of UIBR versus PAR produced in this laboratory was not without debate (see the
analysis of Case 3 for 2007). This again poses the question: how much of a role should master’s students play in our university research centres in general and, more specifically, are they able to play a significant role in UIBR?

One possible answer, linked to some of the case study data, is that if a research centre wishes to have UIBR rather than PAR as the core of its research work (as was the case, for example, with the Agriculture Centre and the Centre-as-Agglomeration), then having senior researchers assisted by post-docs and PhD students seems a more optimal organisational modality – with master’s students having only a peripheral research role. (The research training function for these master’s students would, however, be important.)

This leads to the question of the role of PhD students within South African research centres and units. The evidence from the case studies suggests that they can play an absolutely vital role, as long as this is seen as supportive of the research work being driven by the senior researcher layer.

The value of PhD students as research assistants within use-oriented research groupings of our universities is often underestimated. This value is based especially on two elements. Firstly, because the criteria for a doctoral thesis always stipulate a new knowledge component, PhD thesis work can assist not only with the PAR work of a centre or unit, but even more importantly in carrying forward components of UIBR.14 Secondly, because the NRF norm has until now been to provide PhD bursaries at relatively low levels – at the time of the interviews of 2007 way below R100 000 per annum, compared to the amount of well above R200 000 which they could receive as a salary within government or industry, or even within NGOs – these PhD students have been indirectly providing extremely high-value research labour at low cost to the country (and also to industry, which gains significantly from the UIBR and PAR done at our universities).

These value components of doctoral students within the category of a lower layer of research assistants for our UIBR and PAR need to be appreciated much more fully. This links also to the issue of enhancing our systems of training for PhDs, and the related issue of exploitative levels of payment. This matter is viewed as so important in relation to the micro-contradictions observed within the cases of Part 2 that it is separately considered in the next section.

**Our weak systems of doctoral-level training**

Cooper (2006) contains an extended discussion of potential ways of enhancing PhD training at our universities. The discussion below is thus brief, focusing on data from the case studies. The main points to be made here are the following:

- The roles (of providing postgraduate coursework modules and thesis supervision) that Models A and C university-based larger research centre types are particularly suited to perform, with regard to high-quality training for master’s and PhD students, are usually underestimated.
There are very serious deficiencies in our South African systems of doctoral-level training. This emerges starkly when we compare our systems with international university developments in PhD training in Europe and the USA. These deficiencies are closely linked to our universities being rooted in older first academic transformation modes of PhD training, which are based purely on thesis work without PhD-level courses. Because this is not usually recognised, these deficiencies are often underestimated (see Cooper 2006).

The low levels of funding support for PhD students serve as an enormous deterrent, particularly for black students who might otherwise consider undertaking a doctorate. This will have dire consequences for the long-term reproduction of cohorts of university-based researchers. Moreover, South Africa’s current comparative very low level of PhD graduates internationally, coupled particularly with the low absolute number of black PhDs, undermines the possibility of transformation away from the (now ageing) mainly white (and male) lecturing and research staff (see Figures ii.2–3 in the Introduction to Part 2).

In this context it is useful to recall how the innovative first director of the Centre-as-Agglomeration had deliberately initiated strategies of embedding master’s and PhD training in the research work of each subgroup of his centre from the time of its origin in the early 1980s, and had presented a conference paper in the late 1990s summarising what he viewed as ‘my basic principles’ for such training (see Case 10). It is relevant to reiterate the core of his argument here, which derived in part from his earlier experience of similar research centres overseas in the 1960s.

He had sought to build an engineering-cum-science centre as a ‘network of professors’, with each leading a research subgroup and with one ‘basic principle’ being, as he put it, that ‘research projects are not pursued [only] for their own sake, but as part of a postgraduate programme’:

- Each research subgroup provided an excellent ‘research micro culture’ in which senior researchers mentored master’s and PhD students, and these students themselves continually interacted with and guided each other.
- The academics were interested in the supervision of the theses of their master’s and PhD students, in part because the thesis work affected the success of their own research project work within their respective subgroups.
- The involvement of master’s and PhD students in UIBR and PAR from an early stage of their training indirectly provided them with additional generic skills, such as the importance of appreciating the context of an application, of understanding multidisciplinary modes of research, of working together in a group, and of planning a whole project – skills of great value for later careers in industry and civil society.
- The senior researchers and post-docs of this research centre, and even some of the more advanced PhD students, were able to provide high-quality coursework modules for master’s and PhD students around the niche area or sub-discipline of the centre.
- What the director called the ‘core competency’ of the research methodology of the centre (in this case common computational tools), together with the common
coursework training, further bound postgraduate students and academics into a collegial grouping with common expertise.

The last two points highlight the role of advanced PhD-level coursework training modules – both in general research methodology and in the sub-discipline in which the doctoral theses were being undertaken. In the 1960s, when this director of the Centre-as-Agglomeration was at a North American research-intensive university, this coursework training had become a normal part of any PhD undertaken within American universities. As was cited in Case 10, this director had lamented, 'In [name of the centre] we have succeeded only in offering master's level courses, and have not had the resources to introduce more advanced [PhD] level courses.' So, even though the Centre-as-Agglomeration had built up a network of more than 10 academics with expertise spanning their niche area of research, its director still had serious doubts about their capacity to introduce PhD-level modules.

This example points strongly to the phenomenon, present even at our research-intensive universities, of the widespread and serious lack of a critical mass of quality academics in specific sub-disciplines – academics who are able to offer well-conceived PhD-level coursework modules on a sustainable basis. It is vitally important for our universities to recognise and confront this deficiency. Surely the development of larger and specialist Model A- and C-type research centres can contribute towards alleviating this serious problem? And this would also have advantages over the postgraduate training that, on its own, can be provided by a traditional professor like Prof. Science in a ‘lonely’ single-supervisor mode (along historical Oxbridge lines), or indeed by traditional academic departments rooted in the modes of the first academic transformation.15

Another significant element of our PhD training is the low levels of postgraduate funding. This includes bursaries, an issue already touched on earlier. For example, the director of the Centre-in-a-Faculty (Case 9) at a UoT had argued in his interview of 2000:

My philosophy is to take [PhD students] and pay them properly, i.e. a R60 000 scholarship per annum...[This] is about double what they are getting at this moment in time [from the NRF]...The rewards are tremendous but they [many of the other senior administrators and academics at his UoT] don't see it that way.

This director, despite establishing PhD funding at double the level of the national (NRF) bursaries in 2000, was still battling to recruit and retain PhD students. Here it is useful to add my own personal experience in 2006 in the Department of Sociology at UCT, where one ‘very good’ PhD scholarship to the value of R480 000 (R120 000 per annum over four years) was donated by an ex-postgraduate of our department. This amount was also about double the normal NRF funding level for PhDs in that year, but initially only one African candidate from South Africa applied (among a number of non-African candidates), after a first round of advertising across the country. Informal discussions with potential African candidates in the 30–40-year
age group suggested that leaving their government or industry or NGO jobs, in order to build a new career as a lecturer or researcher after gaining a PhD, was for most of them simply not an option. How many, with a family of dependents and a job paying R350 000 or more per annum, would jump into a PhD for four years at least with a ‘very good’ annual bursary of R120 000?

Despite some improvements in PhD-level bursaries from a variety of sources, including the NRF, over the past few years, there is still a great need for our universities to confront this issue urgently. One proposal that might be pursued is the idea of PhD qualifications being registered under the relevant ‘learnership’ of a SETA and therefore qualifying for learnership funds administered by a SETA. Why not? The PhD student is studying, and at the same time is gaining work experience through doing some undergraduate teaching and undertaking research work as an assistant researcher. S/he is thus an ‘apprentice’ following a combined work-study programme, like all other apprentices who obtain funding for their ‘learnerships’ under SETAs. What better way to train such learners at the top level of the National Qualifications Framework – with their UIBR and PAR thesis work assisting, moreover, in the development of the country, as argued throughout these chapters?

Whether a small portion of the few billions of rands available through the SETAs annually can flow towards such PhD training via learnerships is still an unanswered question. But the issue of how to replace the 80+ per cent white male 50–65-year-old cohort of academics and researchers at our universities with a new generation of younger, largely African scholars of quality and with PhDs needs an urgent response.

**Some crucial sociological factors**

This section draws together some important insights that emerged from the case study analyses about sociological factors which can impact on a use-oriented research centre or unit, impeding or enhancing its research work significantly. This is especially so, in my view, because in many ways these factors encompass the micro-contradictions that result from the current clash at our universities between the differing values and structures of the first and second academic transformations. They need to be understood analytically, not least because they are often missed or viewed as not very important by those involved in the development and management of use-oriented research at our HEIs.

What are here termed ‘sociological’ factors relate to issues of leadership, culture and social structure, as well as history, tradition, memory, etc. in a research grouping and in the HEI. In this discussion the focus will be on three elements that were found to be very important in all the case studies: firstly, the *driver* or research leader of a grouping; secondly, the *social glue* that holds together a group of senior research colleagues; and, lastly, the *micro culture* of research values at the level of subgroup or unit.

In relation to the research driver, a close examination of the 10 use-oriented groupings showed that there was not a single case in which the university institution
and/or government research policies and initiatives were important in the origin of these research centres or units. This raises serious questions (also discussed in the next chapter) about the effectiveness of research policies and research management by HEIs and government bodies, which should surely have played a significant role in the initial establishment of at least some of these cases? In all the cases it was the initiative and energy of the driver or research leader that played a major role. The vitality and vision of the internationally rated professor-scientists heading, for example, the Agriculture Centre, the Centre-as-Agglomeration and the Sustainability Centre, were fundamental to the establishment and growth of the centres at their research-intensive universities. Similarly, the complementary leadership roles of the four professors of the Space Centre were invaluable in the launching of the microsatellite after nearly a decade of hard work, and in the subsequent creation of a spin-off company. Within the centre-type groupings studied at the two Western Cape UoTs (Cases 7, 8 and 9), the driving force was also a dynamic research leader. Such leaders also initiated and drove forward the smaller research groups of the Genes Unit, the Biogenetics Unit and the Commerce Unit.

In terms of what lies in the future, especially for the larger research centres of Model A type at our universities, this finding is both good and bad. On the positive side it shows that there is enormous dynamism and innovation within our third mission-oriented groupings, driven by individual research leaders. However, it would surely be a bad situation if most of our university academic departments were so dependent on only one dynamic leader. On academic terrain generally – in both academic departments and research centres – it is vital for long-term stability and sustainability that when one valued leader departs another highly competent ‘senior’ steps up relatively smoothly to take his/her place. This is exactly what is worrying about many of these innovative yet wobbly use-oriented groupings.

On the negative side, therefore, there are very serious dangers because many of our research centres and units are so dependent on one ‘driver’. Real consolidation or institutionalisation of the second academic transformation will be evident only when a proper and adequate succession process takes place routinely – as happens (it is hoped) for HoDs in our academic departments, according to succession norms established during the first academic transformation. But in most of the 10 case studies it seemed that there were no clear, systematic succession processes in place.

Another point needs to be noted before closing the discussion about research drivers. The case study findings show that it is extremely difficult for a research leader to serve as both director of a use-oriented research group and head of an academic department (or faculty dean). Perhaps this is not as big a problem for PBR work, which is not undertaken under the same time constraints and other pressures from clients, who wish to see timely results from PAR and even from UIBR. But all the evidence suggests that there are severe difficulties in the larger Model A- and C-type research centres, in particular, when their director does not – or cannot – focus primarily on the work of ‘directing’. The director of the Agriculture Centre, for example, pointed out in his interview in 2000 that directing included not only
research management, but also academic leadership within the Centre, and national and international networking with other scholars, as well as long-term research strategising, fund-raising, profiling the image of his Centre, and so on.

Allied to this is the question of undergraduate teaching: all the evidence across a range of the Western Cape interviews suggests that it is extremely difficult for directors and senior researchers of these third mission centres to carry ‘normal’ undergraduate teaching loads while at the same time meeting the output demands from external partners, for the PAR and UIBR work. Nevertheless, postgraduate teaching and supervision can (and should) be part of the normal work expected of our research centres, as noted earlier.

In the light of this, it is encouraging to note that in South Africa the new post-2006 framework for NRF research chairs should contribute towards new initiatives, at least for smaller Model B-type units. A chair award (around R2.5 million per year in 2006, initially for five years) has aimed to provide for a professor to be released from much undergraduate teaching and other administrative duties, with funding support for research assistants and other expenses, in order for concentration on research work in a niche area to be possible.

The second sociological factor referred to above is what I have termed the social glue, which in particular holds together the senior researchers of a research grouping. This was seen most graphically in the Space Lab, where four professors initially came together. This glue was created partly by the fact that they were all male postgraduates of the same university, with some also having acted as PhD supervisors of the others. In addition, when some left to work primarily in the spin-off company, like-minded academics from their department came in to fill the research gaps and even to add new elements to the research programme. Moreover, it was observed how there was a strong commitment in this lab to mentoring junior researchers and also a clear buy-in to the third mission (here linked to U–I relations around microsatellites) – while in the Sustainability Centre, a ‘social glue’ in part held its researchers together over time with a shared commitment to building U–CS research relations.

A few other cases also displayed this positive glue. Conversely, in one or two other cases it was observed that when some social elements went ‘out of joint’ there were serious negative consequences for the research direction and coherence of the centre or unit concerned. There are no easy answers to the question of how this social cohesiveness can be constructed and sustained within our university research groupings, but the first step is undoubtedly to recognise the great importance of such sociological ingredients. This is especially true in the larger research centres of Model A type; whereas in smaller units the social weight of a sole professor counts more, in larger and internally more complex centres, the weight of the senior researcher layer and its glue become much more relevant.

The third sociological factor refers to the ‘micro culture’ of research, especially at the level of the research subgroup within a centre, or in a small stand-alone unit.
Although considered last here, in the case studies this factor emerged as perhaps even more important than ‘research drivers’ or ‘social glue’. Issues of micro culture include research values, day-to-day practices, historical memory, and so on. The evidence suggests that such issues are often neither properly theorised nor planned for when academics and university leaders are trying to build and develop new types of research centres and units.

Many issues related to research micro cultures were encountered across the cases, and a full analysis cannot be developed here. The focus will thus be on those areas observed during the case studies that I feel to be the most seriously challenging.

An issue that arose a few times at the UoTs was linked to the question of a historically weak institutional research culture, which impacted in complex ways on the micro culture of day-to-day research work in the groupings. On the one hand, it was interesting to see how much good research could be developed at a UoT by a resourceful research leader like Prof. Fluids who, during the period 2000–07, transformed a smaller unit into a viable larger centre. Within the other three groupings investigated at UoTs, I was also often surprised by how much research innovation could be achieved. Nevertheless, this historically weak research base cannot be wished away, for, as noted in the ex-technikon cases in Part 2, it is only since the 1990s that the MTech and DTech qualifications have been systematically developed; before this, technikons were focused almost entirely on undergraduate teaching.

In this regard, a comment by the director of a research grouping (Case 8) at one of the UoTs needs to be highlighted again. Referring to the annual April teaching break in the early 1990s, this professor said in 2000: ‘All the doors were closed; the secretaries asked me what I was doing here [coming into the department during the vacation].’ Another UoT professor commented in 2000 that ‘[t]he culture of this whole organisation is not ready yet’ (Case 7). And Prof. Commerce pointed out that while he was the designated coordinator of staff research in his UoT division from 2000 until just before 2007, the division did not come close to the target set in their annual plans for journal publications (Case 5).

The analysis in Part 2 thus pointed to certain pervasive problems at the level of research micro cultures at UoTs. It was noted that their research strategies were sometimes too ambitious, and that UoTs will have teaching as a primary mission for at least some decades to come. But alongside that mission, these cases all strongly suggest that real research progress can be made, especially if only a few research niches are encouraged in each faculty or division, driven forward by a small, selective group of research centres, or even by individual professors with a small group of thesis students. The problems that emerged from the study nevertheless need to be addressed over a longer period, so that research values, norms and practices can ultimately be enhanced significantly at the UoTs.

A similar, more limited but focused research aim might be suggested for all, or at least most, of the historically disadvantaged (historically black) universities
and UoTs. For example, the Genes Unit at a historically disadvantaged institution showed that much could be achieved with exceptionally dynamic leadership. Yet, somewhat unexpectedly, during the second phase of interviews it was found that several members of this Unit – including a post-doc, a senior researcher and a PhD student – had moved across to a new research unit (in the same niche area) at a neighbouring, more research-intensive historically white university.

This example seems to point to a potential long-term research drift in the new South Africa, with some researchers and PhD students at historically disadvantaged HEIs moving towards positions at the historically more advantaged, and more research-intensive, universities. This applies particularly to the Big Five as identified in Table ii.5 in the Introduction to Part 2, which in 2005 were shown to stand out sharply ‘above’ the others in terms of research funding, publications and PhD graduates. But we might also see some drift from the new (post-merger) ‘bottom’ group to the ‘middle’ group of six or seven HEIs that were shown in the same table to be clearly differentiated in such research resources not only from the Big Five but also from the larger and more historically disadvantaged group of institutions ‘below’ them.

The following question arises, introduced towards the end of the Introduction to Part 2: is the post-1994 South African university system now following a pattern, very prevalent internationally, in which a few research-intensive universities begin to absorb much of the national research expertise and funding – giving rise to much higher research outputs by the ‘elite’ group of universities? The findings from the case studies in Part 2 supply a tentative ‘yes’ in answer to this question, particularly if the investigation is focused on the important question of research micro cultures. But the examples of the Genes Unit and the Fluids Centre, both located outside historically ‘elite’ white universities, nevertheless suggest that institutional support and efforts concentrated around some excellent researchers in a limited number of niche areas can result in high-quality research outputs. Such success, owing to the application of ‘judicious constraint’, could be achieved at both historically black universities and ex-technikons. So the message is, potentially: choose a few limited niche areas, at postgraduate-cum-research levels, and concentrate resources in those areas.

The next section completes this analysis by focusing on issues pertaining to the full set of research modalities just noted, namely PBR–UIBR–PAR. The tensions between these various positions or ‘points’ along the research continuum are described, and I ask whether certain institutions, research groupings and academic disciplines should concentrate research only at particular points along this continuum.

**Tensions around PBR, UIBR, PAR and routine consultancy**

As noted at the beginning of this chapter, during the first phase of interviews after 2000 my idea of ‘applied research’ began to be broadened in relation to what I initially called ‘fundamental-applied’ research. But then my encounter with Stokes’s concept of Pasteur’s Quadrant (Chapter 2, Figure 2.1) in 2005 helped to shape a core
finding of this study: that use-oriented research could itself be conceptualised as lying between two points, namely UIBR on the one side and PAR on the other. At the same time (see Chapter 2, Figure 2.2), I introduced the idea of the 'Investigation Work Spectrum', where I distinguished between 'research work' (PBR, UIBR and PAR) at various points on the one side, and 'routine consultancy work' on the other side, in other words, the latter being use-oriented investigation without any 'new knowledge' (research) components.\(^\text{18}\)

One major conclusion drawn from the analysis across the 10 use-oriented cases is that in essence almost all the case studies (except Case 0 of PBR) revealed a complex combination of UIBR and PAR. In other words, while there might be some tensions between the extent to which a research grouping focused on UIBR as opposed to PAR, there was no tension per se resulting from a grouping undertaking both of these as part of its research (third) mission. Over the period of the interview phases some groupings even appeared to shift their focus slightly in terms of UIBR–PAR. Thus in several cases (for example the Space Centre, the Fluids Centre and the Sustainability Centre) there was a concern after 2005 to include stronger elements of UIBR in the work undertaken by the grouping, even if the dominant client demand seemed to be for PAR.

Several questions emerge about the UIBR–PAR relationship and mix, and a number of conclusions arise from the findings of the 10 use-oriented case studies. Seven conclusions and associated hypotheses, which I suggest apply to our HEIs, are now outlined.

Firstly, as just noted, evidence from the Western Cape case studies strongly suggests that there is no inevitable scientific tension involved in combining UIBR with PAR. Both UIBR and PAR offer the opportunity for a research grouping to undertake relevant and high-quality research work, including the production of peer-reviewed publications in highly rated journals. The one aspect of this mix of research modalities in which some tension may arise is financing: PAR is usually much better paid than UIBR, and funding for research on the PAR side is usually much easier to raise (most easily from industry, followed by government, with civil society organisations least able to provide support).

Secondly, and perhaps controversially, the findings suggest that in general research-intensive universities are better resourced than UoTs – materially, and in terms of research micro cultures – to undertake work on the UIBR side. It could therefore be argued that, as a long-term national research strategy, the spread of UIBR–PAR at research-intensive universities should be shifted more towards the basic research side, especially since PBR is already concentrated heavily within this small group of universities. From this would also follow the conclusion that at the UoTs, while some UIBR need not be eschewed by innovative professors, it seems best for most of their research groupings to concentrate on the PAR side. Moreover, such research work would be of great service to industry and government, as well as to civil society organisations, which all have a vital need for such applied research and its
high-quality outputs, focusing on context-specific problem-solving. So there need be nothing mediocre about the quality of PAR produced at these institutions; the difference would be in the kind of research, not in its scientific merit.

Third, and related to the previous point, is the issue of the research focus of what have been referred to as niche areas. As just discussed, it is probably best for research-intensive universities to focus mainly on UIBR, and for UoTs to concentrate on PAR. But the data also suggest that it is important for all types of use-oriented groupings to be clear about their own defined research niche areas. Problems seemed to arise when use-oriented research groupings had only a vaguely defined focus. These problems included a decline in support from clients (usually industry), because the research direction or overall research programme was unclear. This was observed in the virtual Centre-as-Agglomeration, whose 2003 self-review specifically addressed the problem of the dispersed ‘agglomeration’ of its network professors, which had resulted in the lack of a strong overall research programme for the centre – despite the strong research capabilities of the individual professors involved. Something similar was observed for the virtual Centre-as-Department, where, following the departure of its director from Cape Town after the first phase of interviews, the whole research programme became dispersed into the separate missions of the respective academics’ smaller research groups.

In contrast, some of the other centres, especially those structured along Model A lines, built their research around very clear and specific niche areas: the Agriculture Centre around its agri-sector biotechnology, and the Fluids Centre around Prof. Fluids’ expertise in a special subfield of engineering. The results obtained from the data analysis suggest that this concentrated focus imparted numerous benefits, including support from clients who understood exactly what research products would be likely to emerge from the UIBR and PAR of such centres or units. Perhaps Frederick Terman’s vision for engineering science at Stanford just before he joined the university in 1945 is worth repeating: ‘By determining the proper fields on which to concentrate, and then really laying it on those selected spots, we can go places...’ (Terman letter, quoted in Etzkowitz 2002: 108).

Fourth, it is vital, especially at research-intensive universities, to encourage and enhance a symbiotic relationship between PBR and UIBR, for between these two there is no necessary tension. In fact, the opposite is true – as noted in the analysis in Chapter 1 of the EU approach to research and innovation, which since 2005 has stressed ‘frontier research’ alongside its more use-oriented FPs.

With regard to this issue, it should be recalled that Prof. Science of the PBR Case 0 strongly asserted in his interview that basic research since the early 1990s had often been significantly undervalued in academic and professional circles across South Africa. I would concur, especially because PBR has value for its own sake (as the cultural expression of excellence and human creativity) and because, without it, one can have no UIBR, which an aspirant knowledge society like South Africa needs urgently. Thus we need to take seriously some of the disillusionment expressed
by basic science professors about the lack of national respect and low funding for PBR – though the recent interest of the NRF in funding more basic research (to be discussed in Chapter 7) may signal a change in attitude towards PBR. And again, there is perhaps no better example of the success of a symbiotic relationship between PBR and UIBR than the 20-year development programme proposed by Terman after 1945 at Stanford University, linking the physical sciences with electrical engineering, which played no small part in the eventual rise of the electronics industry in nearby Silicon Valley, and of Terman's own PhD students Hewlett and Packard (whose industries were linked to Stanford's engineering research).

The fifth question relates to the fact that, although there is no necessary tension between UIBR and PAR, two interesting phenomena of research drift were observed in a few case studies. On the PAR side, considerable pressure was put on Prof. Commerce, especially from industry-based clients, who wanted not only PAR work but also ‘routine consultancy’, that is, investigation involving more routine data-gathering or work outside his specialist academic niche, which non-academics in private consultancy firms could often undertake as well (see Case 5). Clients requiring this type of work can give rise to a drift by researchers towards such routine consultancy work – unless checked by academics and their universities or UoTs. Other researchers (e.g. in Cases 1 and 7) also experienced such a tension – to the extent that, as noted earlier, one of the Space Lab professors argued for the need to maintain an ‘artificial wall’, conceptually and physically, between their university research work and what he termed the commercial ‘development work’ of the Space company in the nearby science park.

Research drift in the opposite direction was observed in the case of Prof. Biogenetics (Case 4). Here, quite unexpectedly, there was a movement away from PAR and its direct links to industry towards UIBR. In 2000 Prof. Biogenetics was considering forming a small private company with which to link the UIBR and PAR of the university lab, but he later drifted instead in a non-industry direction, producing books and other presentations around a research niche area of biogenetics, in order to inform national and international audiences – both professional and ‘popular’ – about scientific findings in this area of biotechnology.

The conclusion I have drawn, influenced by the cases of Prof. Biogenetics and some others, is that there is far too deterministic a vision – on the part of Etzkowitz and others who hold the triple helix perspective – of a ‘simple and necessary’ drift of university academics under the impact of the second academic transformation towards direct links with industry. The data from the Western Cape case studies suggest, instead, that a more complex relationship exists between UIBR and PAR and even routine consultancy – although use-oriented research for industry is certainly having a significant overall impact on our universities in all sorts of ways.

A sixth issue is that, although many of the researchers involved in the 10 case studies showed great innovation and dynamism in their use-oriented research work across the UIBR–PAR continuum, a linked area that should not to be underestimated is
their educational work, directly and indirectly, for industry, government and civil society organisations. Examples of this abound in the case studies.

In the area of education and training, therefore, these new research centres and units linked to the second academic transformation/third mission seem to have great potential for growth and development.

Seventh, it is necessary to consider how disciplinary differences affect the ways in which the groupings examined in this study link up their UIBR–PAR work with industry, government and civil society, and what the implications are for the application of the second academic transformation/third mission. It is not disputed that there are disciplinary and sub-disciplinary differences in the ways in which various groups undertake UIBR and PAR – for example, even the three biotechnology groupings (Cases 1, 2 and 4) undertook their work differently.

Arising from this seventh point is a broader question, however: is there now a general trend across many disciplines, including the health, business and social sciences, towards a second academic transformation/third mission linking university research to industry and government and sometimes to civil society needs? This study has involved a relatively small sample of use-oriented groupings and could thus not investigate this question in any depth. In addition, the majority of the sample fell on the engineering–natural science side of HEI disciplines. Only two, the Sustainability Centre and the Commerce Unit, were involved in areas defined by the social sciences (in the broad sense) – yet here too it was clear that the forces of the second academic transformation/third mission were having a substantial impact.

What has become clear from the analyses in Parts 1 and 2 is that many biogenetics professors have since the 1980s become much more linked to industry and to a general development of biotechnology, internationally and within the Western Cape (albeit here after the 1990s). Over the last two decades, therefore, biotechnology academics in particular have led the way in the expansion of the second academic transformation – just as Terman and other ‘electronic-physicists’ provided the early foundations for this ‘revolution’ in the USA during and after the Second World War. In the Western Cape, engineering–science groupings – based not only in the field of electrical engineering but in a range of engineering–science fields, for example space, mechanics, microbiology and fluids – have also followed this trend. But I would go much further: in many of the chapters I have argued that in essence we are seeing the emergence of a ‘knowledge economy’ – and even more deeply a ‘knowledge society’ – linked to what I have called the third capitalist industrial revolution taking place globally and within each country, and that in the twenty-first century university research will need to confront a range of broader issues impacting on civil society, including civil society in South Africa. These issues include new modes of planning cities, questions of housing and transport, environmental challenges and so on. It seems very probable, then, that this academic movement towards I-G-CS links – concentrated mainly in subfields of the applied sciences and engineering at present – will spill over to other disciplines, including those focused on
commerce, sustainability, political science, etc., thus spreading the second academic transformation/third mission across a far wider area of the academic spectrum. I therefore hypothesise (bearing in mind the qualifications mentioned above) that:

- the second academic transformation and third mission are having generalised effects across many disciplines, albeit currently more strongly in some (e.g. biogenetics) and less strongly in others (e.g. sociology);
- although the majority of the 10 case studies related to disciplinary fields of engineering or applied natural sciences, the conclusions – all at a very general level of analysis – being drawn here also apply to use-oriented research centres and units in the fields of social, health and business sciences (and perhaps further afield);
- during the twenty-first century, use-oriented research (UIBR and PAR) linked to the knowledge economy/society will encompass far more of the social, health and business sciences, so that the general conclusions of this chapter will apply increasingly to trends emerging in these disciplines. Moreover, it has been argued that the spread of UIBR and PAR is linked to the growth of new forms of research groupings classified as Model A, B and C types (and variations in between); thus newly emerging research groupings along the lines of these three model types, in the social and allied sciences, will surely become involved in a complex mix of both UIBR and PAR, depending on the context, as observed for the 10 cases examined in Part 2.

The orphan fourth helix of U–CS research relations

The discussion in Chapter 3 of the international dominance of the triple helix, and the relative ‘orphan’ status of the fourth helix of U–CS research relations, is reconsidered here in relation to the Western Cape cases. The specific question that needs to be addressed is why, when links are being developed and established by academics with the wider society, these are usually with industry or national government, rather than with civil society organisations such as trade unions, community organisations, local government bodies and NGOs.

It was argued in the first part of this chapter that, theoretically, the basic forms and structures of U–I research linkages should be no different from those of U–CS relations. So, theoretically, one should have observed a much greater involvement with civil society bodies across the 10 cases. Given the discussion at the end of the previous section, this orphan status of U–CS linkages cannot be laid entirely at the door of disciplinary differences.

From the case study analysis it has become clear that one important issue enhancing U–I research linkages is the fact that ‘funding is fundamental’ for such research. In most of the cases, industry funding was observed to be absolutely crucial to their work and even their survival. Clearly, therefore, the triple helix, with government often playing the role of coordinator, is sustained directly through industry funding. And of course this is linked to the third capitalist industrial revolution, which I have been arguing does significantly underlie many of these trends.
Nevertheless, it is not enough to suggest that the answer can be found solely in terms of ‘industry as funding agency’, however important this is for South African university research. The issue of ‘academic identity’ clearly proved to be another important concern for researchers, according to data emerging from the interviews, which often referred to pressures for peer-reviewed publication and other forms of internationally recognised research outputs. In only one case was a third factor cited as of equivalent importance to the researchers: the staff of the Sustainability Centre (Case 6) were prepared – through involvement in the Gugulethu township project – to sacrifice some industry funding as well as some traditional publications, in order to produce reports and pamphlets on sustainability issues for civil society organisations. Their self-conception or self-identity as researchers, committed to a third mission of building U–CS relations, was a force in itself in this case, shaping their decision to make these sacrifices.

This example therefore suggests that there are at least three important pressures shaping this use-oriented research: i) finance; ii) traditional academic publication; and iii) researcher self-identity. Interestingly, it was observed that in most Western Cape cases involved in industry funding, there was a perceived clash or role conflict between third mission work for industry (resulting often in monographs and reports) and ‘traditional’ second mission research work oriented to peer-reviewed publications (especially in international journals). In fact, this conflict, revolving around a dual self-identity as a ‘traditional’ academic rooted de facto in the first academic transformation but also as a ‘new’ academic undertaking third mission work for industry, was a significant theme across most cases. The central clash, when it occurred, was thus between forces of the triple helix and forces of academic tradition in their universities.

Only in the Sustainability Centre was an additional conflict clearly observed: whether to do research work for civil society rather than I-G (the latter having better finances), or to concentrate on traditional peer-reviewed publications as a third option. These conflicts do not revolve only around funding but also relate to how the researchers ‘see themselves’. The importance of researcher identity and its various components needs further research; my case studies only open up a few significant questions. Nevertheless, I am arguing that it is not only finances or pressure to produce traditional publications that can explain why the 10 use-oriented case studies revealed so little work linked to U–CS relations. I propose that how university researchers view their place and role in relation to civil society organisations like trade unions, NGOs and community organisations also plays an important part.

Turning to another factor in U–CS relations – the perception of the importance of university research in the new knowledge society – I have already suggested that even for U–I research relations there appeared to be a general underestimation of the ‘innovation’ role of university knowledge. I proposed at the start of this chapter that although U–I research linkages in the Western Cape were emerging more strongly, there appeared to be an absence of ‘innovation anxiety’ about the urgent need for universities to provide cutting-edge research in the interests of achieving
international economic competitive advantage. I would propose that this extends even more so to the issue of U–CS relations: interview data suggested that there was no perceived urgent need for university research groupings to play a significant role in the development needs of civil society. Even perhaps the Sustainability Centre, where a developmental ‘third mission’ for civil society was clearly present, did not always view this as vital, in other words, that without such university involvement, the socio-economic problems faced by civic groups could not be confronted at all adequately.

This links to a general question posed at certain points in earlier chapters: are South African universities and their research groupings self-aware about a new industrial, ‘knowledge economy’ revolution, internationally, as well as the vital need for ‘academic transformations’ to take place at our universities in order to facilitate the development of such a knowledge society? This idea – of research groupings consciously playing a vital role in ‘unlocking knowledge’ for civil society organisations – does not appear to be strongly present in current thinking among such groupings, if the interview findings are considered across the cases.

This unlocking of knowledge by the 10 use-oriented research groupings may also be considered from the angle of Western Cape regional social-economic–cultural development. As discussed in Chapter 3, over the past decade the OECD in particular has given the lead in ideas about ‘regional systems of innovation’ and ‘learning regions’. Yet the evidence across the 10 cases suggests an even lower level of ‘innovation anxiety’ about their role in the regional compared to the national economy. Only in the Agriculture Centre was there found to be a strong perception of a regional role in providing economic competitiveness on an international terrain. Most of the others saw their research role in the national economy in broad (and usually vague) terms.

If there was a relatively narrow view of their regional economic role, the view of their potentially broader role in regional socio-economic–cultural development was even narrower. This role would include development issues such as housing, transport and even the arts (e.g. theatres and museums). Such development issues are often best addressed at a regional level, yet only the work of the Sustainability Centre seemed to have some of this orientation. A discourse about a ‘fourth helix’ and associated regional involvement was found to be significantly absent in interviews for other cases.

This conclusion should be very worrying, especially in a developing country such as South Africa. Here, as discussed in earlier chapters, well over 50 per cent of the population is not economically active in large and medium firms – in other words, U–I research relations do not usually impact on them in a direct way. But even more importantly, I have hypothesised that U–CS relations, especially at a regional level, are needed in order to help address some of the acute socio-economic–cultural problems faced by civil society in poor residential areas and their more ‘informal’ economies. Thus, while there are funding factors inhibiting the development of stronger U–CS research relations, and also factors related to questions of academic
identity, there also appears to be an absence of ideas about a learning region, and its regional innovation system and local knowledge society, and about how a university might much more constructively develop links with its locality. Such conceptual ‘absences’ provide some of the focus for discussion in the concluding chapter.

Notes
1 As noted in Appendix 1, the 10 use-oriented cases were selected randomly without any specification that their external partners be centred around either industry, government or civil society.
2 As discussed in Part 1, this is my extension of Etzkowitz’s narrower idea of ‘economic’ development as the focus of the third mission.
3 See, for example, the work of Lorentzen (2008) and Kruss (2005, 2009) for case studies of other university research groups in relation to research work for industry in the Western Cape and South Africa more generally. Here, too, in numerous (but not all) cases there appears to be a general lack of ‘innovation anxiety’ among university researchers linked to industry.
4 As stressed in Chapter 3, such a definition of a ‘stand-alone’ centre does not mean it cannot be located formally in an academic department (though this might be unusual). The core issue is that actual ‘line management’ of the research mission and research finances (under the centre director and often an advisory board) must be vested in the centre and not the department.
5 In essence, too, I am pointing here to the fact that such ‘autonomy’ of research for professors within a Model C virtual type (network of professors) is rooted in the system of departmentally based tenure (and ability of such professor-PIs to acquire their own research funding), that is, an autonomy based moreover on the academic norms originating in the German professor-chair system of the first academic transformation of the 1800s (see Chapter 3).
6 In 2000, six of the 10 use-oriented cases were located in a department and four in a faculty (two of these spanned two faculties). However, at each of the five HEIs visited there were other such groupings, which spanned both departments and faculties or occasionally were even located in the institution as a whole, under its senior management.
7 There are numerous examples at our HEIs of mono-disciplinary research centres. The Sustainability Centre and the Fluids Centre came close to approximating these, with each located in a department of the respective discipline or field in which its research niche fell.
8 Some activities of Prof. Biogenetics, as noted in Case 4, involving presentations and talks to international bodies about issues of genetics and research, might nonetheless be included as part of U-CS (international) linkages.
9 These proposals are derived not only from an examination of the case study data but also from discussions with various research managers, directors and groupings at our HEIs over a number of years since the study began in 2000.
10 The term ‘associate professor-researcher’ is used deliberately to distinguish this mid-career layer of seniors – usually around 35–45 years old – not only from the post-doc layer below but also from the research director above, who leads a research centre or unit. (The position
of director has been considered as part of the new NRF research chairs initiative, but this will not make any provision for a layer of 'seniors' just below director level.)

11 See Boyer (1990), especially on the ‘scholarship of application’ and of ‘integration’.

12 A workshop I attended at my university in 2010 described how specific tax concessions had been negotiated by universities in South Africa for post-docs. I would see this as de facto recognition of the uncompetitiveness of current post-doc ‘salaries’, which have been defined as study ‘fellowships’ (hence tax-free).

13 See Cooper (2006), where it is noted that for a master’s in Europe, under the revised three-year (bachelor) and two-year (master’s) structure of the 1999 Bologna Declaration, this five-year training will often culminate in a master’s-level research project, but that real research, requiring the production of new knowledge, begins only after these five years, with PhD training.

14 Of course, this new knowledge component also helps to enhance curiosity-oriented research or PBR, but the potential role of PhD students in more use-oriented research work is highlighted here because this element is often missed.

15 See Clark (1993) for a valuable comparative analysis of PhD systems in the USA, Britain, Germany, France and Japan, in which some of the advantages of the American system are highlighted. Note, however, that over the past decade in Europe coursework components of PhD training, especially in research methodology, have begun to be introduced more frequently (Cooper 2006).

16 This is not intended as a judgement of the composition of this positive collegiality. Of course, all compositions of this and other research groupings – white, male, English-speaking, Afrikaans-speaking, etc. – need to be radically reconstituted at our universities. The point being made here is simply that the social glue with which research groupings are constructed is a vital and often underestimated factor affecting their positive functionality.

17 See, for example, leading journals such as Social Studies of Science, Science and Public Policy, Research Policy, etc. which now include interesting studies in every issue that deal, either directly or indirectly, with what is referred to here as the ‘micro culture’ of a small research group.

18 See discussion in Chapter 2, following the OECD Frascati Manual distinction of ‘research’ versus ‘non-research’ work of routine testing.

19 See, for example, the interesting socio-economic-cultural development roles currently being played by Newcastle University (UK) and Michigan State University (USA) in their respective regions, as described in Goddard (2009).
The idea of a second academic transformation: Implications for new concepts and new policies

Missing discourses and absent concepts

The central argument running through all the previous chapters is that we in the Western Cape, and in South Africa more generally, need to recognise our own emergent second academic transformation, linked to a growing third university mission of socio-economic-cultural development. I have proposed that this is taking place, albeit unevenly and often unrecognised, within the universities (including UoTs), as evidenced by the 10 cases of dynamic and innovative ‘applied’ research groupings in the Western Cape examined in detail in Part 2. The remarkable efforts made by many of them to overcome a range of inhibiting factors in order to enhance what I have called their use-oriented research work (a combination of UIBR and PAR) need to be recognised. But more importantly they, and many other centres and units like them, need assistance in the form of new policies, especially regarding the input of substantial research financing and support for new systems of research organisation within our universities. In confronting the evidence of what I have termed the ‘chaos and creativity’ taking place inside these 10 cases in Chapter 6, I have argued that our universities – of which we are in many ways justifiably proud – are still largely locked into older first academic transformation practices and structures, and are shaped by discourses that miss the revolutionary transformations taking place right inside many of their own new research centres, units and networks. As the title of this chapter asserts, we are sorely in need of ‘new concepts and new policies’.

The second section of this chapter considers the question of where some new research policy initiatives might be focused. However, the proposals for new policies are rooted in my claim that these must be based on new concepts and new discourses, and the first section of the chapter addresses this concern. For what I have sought to establish across the previous chapters is that there are absent concepts and missing discourses: in order to move towards new research policies for enhancing third mission research work within our universities, we need a prior acceptance of new ways of seeing the current situation of chaos and creativity. In the previous chapter I explored this idea in relation to a series of ‘micro-contradictions’ that could be observed across most, or all, of the 10 cases in their UIBR-cum-PAR work. These, I argued, involved factors (such as weak funding, lack of a career track for senior researchers, underdevelopment of research missions linked to regional systems of innovation, etc.) that were seriously inhibiting use-oriented research work. I hypothesised there that to change these into ‘enhancing factors’, a prior
understanding is needed that many of the problems are linked to a clash of values and systems within our universities, involving structural contradictions between an older first and a new second academic transformation. It is therefore important in this first section of the chapter to review the conceptual issues that, in the Introduction to Part 1, I called the ‘theoretical scaffolding’ of this book. This conceptual framework needs to be consolidated here, since it must provide the basis for the proposed new policies that will be discussed in the latter part of this chapter.

The idea of a post-1970s third capitalist industrial revolution

It is necessary to start with this ‘missing discourse’ of a third capitalist industrial revolution, since without it my hypothesis of the crucial symbiotic relationship (see Table 3.1, Chapter 3) between this industrial revolution and a global second academic transformation cannot be grasped as central to the whole theoretical scaffolding.

In the Introduction to Part 1, I sought to highlight a number of crucial theoretical points about the new industrial revolution that began to take shape after the 1970s: i) that this new industrial revolution is really a significant break with the old, being based much more on a knowledge economy and even (increasingly) on a broader ‘knowledge society’; ii) that this supports Etzkowitz’s hypothesis (see Chapter 1) that universities in the new knowledge economy are being transformed from a secondary to a primary institution; and iii) that unlike the first and second capitalist industrial revolutions, this post-1970s revolution incorporates TNCs and certain other sectors of society that need university science for their very survival, which places universities much more centre stage. This, I also argued, underlies the new international mood of ‘innovation anxiety’ and associated ideas about NSIs, which are directly linked, for example, to research efforts in the USA to build new science and engineering research centres and to EU efforts to link their FPs of research (NoEs) and ‘frontier science’ to the competitive needs of European industry (Chapter 1).

In South Africa, I argued in Chapter 6, the situation has been different: while the directors and research staff of centres and units in the case studies clearly saw the value of U–I research links, there was a relative absence of innovation anxiety – at least in the sense that very few interviewees saw university research as absolutely vital to the development of our national industry. In addition, it was observed from the review of policies towards building an NSI in South Africa since the 1990s (in the Introduction to Part 2), that while S&T policy discourse did begin to focus increasingly on ideas about a knowledge economy and innovation, the role of universities in this process was never clearly articulated. In other words, the issue of ‘unlocking university knowledge’ was a conceptual absence, never discussed in the way it is being put forward in S&T policy discourse in the USA, Europe and parts of other continents.

This points to at least one missing discourse within our universities, and also in the wider society: there is no clear articulation or understanding yet of the vital importance – at least for the most ‘modern’ sectors of our economy – of the
The idea of a second academic transformation and important associated concepts

An interesting insight into some dominant public discourses about our universities can be gleaned from the articles, mainly by academics, that have featured (usually monthly) in the higher education supplement in the Mail & Guardian (M&G) newspaper for the past few years. Although more rigorous content analysis would be valuable, my superficial assessment is that the dominant themes often revolve around the ‘market economy’ penetrating the values of academe, and ‘the state’ beginning to penetrate into the realms of academic autonomy. It strikes me that in many ways this discourse used by academics writing in the M&G is a ‘reactionary’ response (in the literal meaning of the word): a reaction by professors of an older first academic transformation against what are perceived as new forces of the market and the state. Although such discourses are not without importance, what is missing from them is any conceptual framework about changing forms of industrial production (in ICT, in biotechnology, even in city design), and of associated societal claims on academic science to become more third mission-oriented for the benefit of a knowledge society. Even when serious academic research on issues of university structure and practice is undertaken, it is often along the lines of the article ‘At the Chalk Face: Managerialism and the Changing Academic Workplace 1995–2001’ (Webster & Mosoetsa 2001), where the transformation process is viewed in terms of the growing power of a central university administration, hence ‘managerialism’. While the analysis is valuable in those terms, what is missing is an exploration of ideas about a massive new academic transformation linked to momentous changes ushered in by a third capitalist industrial revolution at the level of production.

When we turn to the data from the Western Cape case studies themselves, however, it must be acknowledged (as discussed in the previous chapter) that although the research directors and researchers at these centres and units did not explicitly refer to the concept of a triple helix or even directly to U–I–G relations, the research connections between their own research groupings and especially industry, and to a lesser extent government, were very much present, both in their minds and in their research activities. In addition, while they did not specifically refer to a ‘third mission’, the idea of undertaking research for external stakeholders (especially industry) was
central to their work, conceptually and in practice. So, at least with reference to the case studies, it could be argued that ideas about a ‘third mission’ and ‘triple helix’ – both central to the way I (and Etzkowitz) have constructed the idea of a ‘second academic transformation’ – were implied in their work, if not expressed explicitly.

However, what of two other concepts that I (but not Etzkowitz) have also associated directly with the idea of a second academic transformation: UIBR and ‘new, larger centre types of research organisation’?

Regarding UIBR, with one or two exceptions most interviewees did not clearly distinguish between UIBR and PAR in their work. In addition, there was generally little discussion about the importance of fundamental science as the basis of their third mission activities, though if questioned directly about it they did acknowledge its importance.

What this points to is an absence at our universities (and even, though to a lesser degree, at research-intensive universities globally) of the idea that UIBR rather than PAR comprises much of what is embedded in university third mission research activities. Or, as I have put it in previous chapters, that research-intensive universities are often best at providing fundamental or basic research with a broad ‘use-orientation/inspiration’, and that other stakeholders (e.g. industry) are usually better resourced to undertake PAR and even more routine consultancy work that can transform the research into a product, that is, into actual outputs in the innovation process. This also suggests, however, that the significant stress of South Africa’s recent national S&T policies on directly applied research, and even on direct commercial outputs (e.g. in THRIP, BRIC and even the choice of the NRF focus areas), while not a problem per se, can have seriously detrimental consequences if, at the same time, PBR and UIBR are undervalued and underfunded nationally.

In previous chapters I have thus proposed that in the post-1994 period, an undervaluing of the more basic side of the research spectrum has often been prevalent in our new national research policy discourses. This has also partly impacted on the university researchers themselves, who in my interviews often failed to articulate the value of the more fundamental side of their research (PBR and UIBR) alongside their more PAR activities. Very recently we might have seen the beginnings of a new appreciation of the more basic side, for example with the initiation by the NRF of its ‘Blue Skies Research Programme’ in 2008. However, it seems there has been confusion about the ‘parameters of blue sky research’ and ‘the objectives of the programme’. I suggest that this uncertainty is directly related to the historical absence of a national debate, also within our universities, on how to conceptualise ‘use-inspired’ research as something more than PAR (i.e. embodying UIBR as well); and, as importantly, of how both UIBR and PAR depend, for their lifeblood, on PBR itself. We must hope that this new step by the NRF into this area of debate – essential to a proper understanding of the essence of the second academic transformation – will begin to bear fruit in terms of new discourses about the role of more basic research in a university’s third mission.
Regarding the second associated concept, of ‘new centre types’, I would argue that just as important as the absence in understanding of UIBR is the absence of understanding that what I have termed the new Model A research centres and the new Model C virtual centres are different and novel modes of research organisation. They embody new internal structures, as well as new values and norms of research organisation, all of which are essentially part of a second academic transformation, as I have proposed throughout this study. Yet they are continually perceived as essentially ‘add-ons’ to the ‘normal’ university structures.

In previous chapters I sought to show that what Geiger (1990, 2004) calls ORUs do have a long history, extending back to nineteenth-century space observatories and even archaeological museums. I have nevertheless stressed that the Model A and Model C centre types discussed in this book (often referred to as CoEs and NoEs), and their mushrooming and consolidation across universities globally since the 1980s, are very much the result of the second academic transformation. This, I have suggested, is because they embody what I have called ‘efficiency functionalities’ that are very much needed by external stakeholders: these centre-type structures provide i) a clearly directed research mission, ii) a critical mass of senior researchers, iii) continuity and predictability, and iv) capacity for professional and postgraduate training.

It is vital that a new conceptual framework be developed for such centre types. At present, the interview data suggest strongly that they are viewed by their universities and the centre research staff themselves as just ‘a small addition’ to existing university systems. In contrast, I have argued throughout that because such centre types are novel forms, which structurally help to facilitate the third mission of the second academic transformation, they continually clash with the values and systems of the first academic transformation. Because of this, the problems described as micro-contradictions within these centres – like lack of a career track for senior researchers, underfunding of their administrative structures, and the absence of succession rules for research directors – cannot be fixed by means of small adjustments within first academic transformation structures. Instead, the first step is to recognise, conceptually, that these centre types are part of a new academic revolution. If they are viewed in terms of this revolution, and not as part of the old order, then new policies can be developed to enhance their growth and functionality.

I hope, therefore, that this discussion has shown that we need a conceptual leap in understanding that not only is a second academic transformation expanding across universities, but also that the concepts of UIBR and new centre types are central to an appreciation of the nature of this academic transformation.

The idea of regional innovation systems

A similar conceptual leap needs to be made with regard to the concept of a university’s role in its regional ‘socio-economic–cultural’ system – what, in the broad sense, has been conceptualised as a regional innovation system.
It was suggested in Chapter 3 that one of the most exciting developments over the past decade concerning the idea of a second academic transformation has been a recognition in the publications of the OECD and other international organisations of the importance of new concepts like ‘learning region’ and ‘regional innovation system’. This links directly to a university’s vital third mission role in its own surrounding region, or in what I call its ‘local knowledge society’. It was further noted that all the talk of globalisation notwithstanding, TNCs require a ‘geographical embeddedness’ in order to operate; or, as Dicken (2003) has put it, in the global world ‘place still matters’. And examples were given of many leading international research-intensive universities (e.g. Harvard and Oxford) that are reconceptualising their regional developmental roles, including allied research activities, in a much more serious way.

Yet in the interview data it was again noted that only two of the cases (the Agriculture Centre and the Sustainability Centre) had developed specific research practices around a regional role, with moreover only one (the Agriculture Centre) explicitly articulating the importance of its regional role concerning its agri-sector’s international economic competitiveness. In all the others the interviews revealed an absence of any explicit discourse about regional innovation and, more importantly, even an absence of any implicit idea of this in their practices. The vast majority of the cases saw their third mission research work as nationally oriented (e.g. to industry), rather than having a specific regional Western Cape (or local Cape Town) role.

This is further evidence, I would suggest, of the underdevelopment of ideas and perspectives about the need for a second academic transformation/third mission at our universities generally; and, more specifically, of a lack of recognition about how universities internationally are orienting part of their third mission work much more directly to developments in their own region.

The idea of a fourth helix as interconnected with the triple helix

I have defined the fourth helix as U–CS research relations – specifically ‘civic engaged scholarship’ by university researchers with civil society bodies and groups such as labour and community organisations, women’s and environmental groups, and so on, as well as municipal and regional civic structures. Clearly, by this definition, universities in association with civil society can contribute very significantly through research and teaching activities to the enhancement of a regional innovation system, and thereby contribute to the unlocking of knowledge for the broader socio-economic–cultural development of the local knowledge society. I have specifically used the latter term since I have argued throughout this study that universities can play a role not only in economic development narrowly conceived, but can also collaborate with civil society in developing new transport and housing systems, new health organisations, new cultural works, etc. at a regional level. And of course across the chapters I have stressed the potential role of U–CS research relations at national level too.

Sadly, however, the idea of such U–CS relations at both national and regional/local levels was significantly absent among most of the 10 use-oriented cases. As
noted in the previous chapter, part of this absence might be ascribed to disciplinary differences; but I hypothesised nonetheless that the absence of an idea of ‘civic engaged scholarship’ does significantly explain why so few of these cases were found to have established U–CS relations as part of their third mission.

In the next section I shall propose some possible policy initiatives for strengthening U–CS research relations in our universities, but it is important here to conclude with a summary of theoretical propositions put forward about U–CS compared to U–I–G relations in earlier discussions, since these have policy implications. Essentially, I have hypothesised (in Chapters 3 and 6) that there are no fundamental theoretical differences between research work that embodies engaged scholarship with civil society and research that engages with industry. All engaged scholarship, I argued, must i) be based on rigorous scholarship, ii) be collaborative, wherever possible, and iii) be oriented towards intentional public benefits. I therefore propose that we need to conceptualise a quadruple-helix structure that encompasses the interaction of U with I+G+CS. None of these four are privileged in this new conception – how U interconnects with each in terms of engaged scholarship depends primarily on the context, not on any predisposition that industry or government is especially in need of engagement. This four-part relationship is given diagrammatic form in Figure 7.1.

The U–CS research relations should therefore be neither of orphan or marginal status, nor be elevated above all other relations with external stakeholders (as is sometimes suggested in debates about community engagement).2 Instead, ‘engaged scholarship’ with industry or government or civil society should be viewed as a normal practice for university academics – as normal as teaching students and doing research for peer-reviewed publications – and national (and regional) innovation policies should encompass all these forms of third mission activities.

Some policy implications of this reconceptualisation in the current South African economic and social context will be explored below.

Figure 7.1 A reconceptualised quadruple helix
Some new policy implications

The aim of this brief section is to stimulate debate around a few selected and even controversial proposals for new policy initiatives in three crucial areas, rather than trying to cover a wide range of areas in which diverse policy issues have emerged. My aim here is also to establish a link between new concepts highlighted in the first part of this chapter and their implications for policy formulation in these selected areas.

Building new centre types, especially Model A real centres

I believe that if new centre types (Models A and C) and what I have termed their relative ‘efficient functionality’ can be recognised as part of emergent new modes of research organisation, directly linked to the second academic transformation and third mission, this in itself will be a big step forward. In fact, despite the two recent organisational initiatives to enhance research at South African universities – the ‘centres of excellence’ from 2004, and the ‘research chairs’ from 2006 – there has not actually been a theoretical debate about why such forms have been chosen for enhancement. And while the NRF website on its ‘South African Research Chairs Initiative’ page (NRF SARChI 2010) states that this is aimed at ‘increasingly forging new public-private partnerships in order to give South African universities and industry a competitive edge’, no rationale is provided for why this chair system (itself modelled on the Canadian research chair initiative discussed in Chapter 3) has been chosen.

In regard to the research chair initiative, where the aim was to create 210 such chairs by 2010 (to date fewer than 100 have been established), I have argued in Chapter 6 that this will serve to consolidate small Model B-type units around a professor, supported by postgraduates and a few post-docs. (The SARChI subcategories of funding are themselves directly specified, for each chair, to provide for the latter two categories of research support, but without a funding category for a layer of more senior researchers, except for the chair itself.) Interestingly, on the NRF SARChI website the heading is ‘South African Research Chairs and Rated Researchers Incentive Funding’, in essence showing that its thrust is linked to enhancing the research output of individual rated professors as PIs.

Similarly, the initiative for developing CoEs, which are essentially networks of researchers across a few universities around a common niche area (e.g. birds and biodiversity conservation), seems to have been influenced by the Canadian NoEs and similar ‘virtual centre’ or ‘network’ models in some other countries (see Chapter 3; also NRF CoE 2010). This initiative seems not to have taken off as strongly as the SARChI (six CoEs were initially established in 2004, with one more so far thereafter), but again the rationale for choosing this model is not clear.

However, as I have argued in Chapter 6, this CoE initiative will in effect serve to consolidate a Model C virtual centre-type network of professor-researchers. This is not at all a bad thing, in my view, for as I have discussed in detail in Chapter 6, it is important to develop and expand streams of small Model B-type units (through the SARChI initiative) as well as Model C-type virtual centres (like these CoEs) across
our universities. The problem, in terms of my arguments, is that a third stream – of Model A-type real centres – is missing. Thus only two, not three, streams are flowing into our ‘river’ of university use-oriented research, resulting in the lack of what I regard as a most crucial component.

I believe it is absolutely vital for a new national discourse to emerge that recognises the value of a Model A centre whose core internal structure comprises a research director and four or five senior researchers, each leading subgroups, supported by a solid central administrative and technical infrastructure. Much evidence for the value of such a centre type has been provided in detail across the case studies and also in the arguments of Chapter 6, so I will not repeat my argument here. However, it must be stressed that a new research grouping type with three absolutely essential elements – a clearly oriented third mission, a director who has the vision and powers to realise this mission, and a critical mass of senior researchers (who are ‘above’ the post-docs and postgraduates) – is needed to enable our universities to enhance their third mission activities for industry and civil society. In the previous chapter I argued further that in numerous ways the Model A type has greater functionality than the other models in the performance of third mission activities.

As the first steps in developing a broader set of policy initiatives that are required – not only to recognise Model A centres as part of a second academic transformation, but also to help institutionalise these centres within the very structures of our universities – I would suggest that within universities we need policy discussions about:

- formal rules for locating centres within departments (in some cases) and outside departments (in other cases) and for specifying to whom a centre director in each case should formally report – an HoD, a dean, or another senior university structure;
- adequate reimbursement for centres within a university for the teaching and postgraduate supervision undertaken by centre researchers;
- succession rules for centre directors, which should be drawn up and implemented more formally;
- formal career tracks and associated employee benefits (e.g. medical aid) for centre researchers, particularly senior researchers.

The last point is so crucial that further discussion about this continues in the section below. Essentially, however, the exhortation for policy discussions around all these points is meant to encourage steps to institutionalise these Model A centres within South African universities – not as add-ons but as new structures that cannot be fitted easily into the older system of values, norms and rules of the first academic transformation.

In conclusion, I propose that all the findings of the 10 use-oriented case studies in Part 2 point towards an urgent need for a debate inside our universities, and also at relevant national levels, about the importance and relevance of consolidating Model A-type university centres. If this does not occur, we are likely to see a continuous process of rise and fall of many of these embryonic, dynamic and valuable centres, as was evident in some of the cases of the Western Cape investigation.
A career track for senior researchers and expanded research funding for centres and units

Of the points just mentioned about how to institutionalise a Model A centre type within our universities, I wish to highlight the policy issue of the need for a career track for senior researchers. This is because, as I have argued in earlier chapters, the departmentally based, tenured professor ‘researcher-lecturer’ has been the anchor of university systems globally for the past two centuries. The arguments for the creation of a parallel career track providing longer-term security and promotion opportunities for researchers within the new centre types, alongside the existing career track for our normal researcher-lecturers (see Figure 6.3), need not be repeated here. It is sufficient to stress that data across the cases in Part 2 showed how the absence of proper career tracks for researchers, particularly for the seniors, led to enormous problems and even crises in a number of the cases. I would put this forward as the main factor inhibiting the third mission research work of centres, both Model A and Model C types.

Linked to this, as also argued in the previous chapter, is the fact that funding is fundamental in financing such career tracks. I therefore reiterate an earlier point made there, that our whole system of national subsidy formulae, which prioritises the funding of student enrolment numbers (and thus teaching, and therefore implicitly ‘researcher-lecturer’ salaries), needs to be debated. If UIBR and PAR (and also PBR) are to be given higher status and support in our universities, such debates around the policy implications of existing funding formulae cannot be avoided, in my view. But as I argued earlier, even changing the funding formulae will not yield the kinds of funds needed to consolidate much more strongly the research centres and units necessary for our university third mission activities, for both industry and civil society.

At the South Africa–Canada Research Chairs Colloquium held in 2008 in Cape Town, where the Canadian research system (including its research chairs and CoEs) was outlined (see Chapter 3), it became clear that Canadian funding for these initiatives was quite substantially higher than in the similar new South African initiatives. But as important is the fact that, from the Canadian data presented (Charette 2008; Gauthier 2008), it was clear that the Canadian university research system of funding is not only at a higher level, but is much more integrated across a range of structures. For example, Canadian research groups could draw on funding across a spectrum of funding agencies and ‘innovation’ bodies, including provincial governments. In contrast, the Introduction to Part 2 suggested that in South Africa almost all research funding initiatives (e.g. THRIP, BRIC) are driven by a few government departments like the DST or Department of Trade and Industry which are outside the education sphere (including the recently established Department of Higher Education and Training). The South African university research funding system thus not only appears to be more fragmented than the Canadian system but, crucially, our Ministry of Higher Education has often stood on the sidelines while other departments have taken the lead in research development initiatives.
This again highlights the fact that our university system is stuck in ideologies and practices of the first academic transformation with its focus on the first two missions (teaching and basic research).

In Chapter 6, therefore, I floated a few ideas about ways of enhancing our national research funding, including the concept of industry-sector research levy systems coordinated by government (similar to what was referred to as the Agri-Sector Industry Network for Case 1), and the concept of PhD 'learnerships', whereby funding from the national system of learnerships could in part be channelled into PhD training (since doctoral students combine some research and teaching 'work' with their 'learning' around a PhD thesis). What is crucial here is not that these ideas be taken on board in this specific form, but rather that there is an urgency for development of new ideas – linked to what I have termed an 'innovation anxiety' – about how we can significantly increase our university research and PhD funding support levels. And in order for this funding system to become more integrated across its segments, it is vital that the new Ministry of Higher Education and Training play a much more central steering and ideas-driven role than has occurred since the formal initiatives to develop an NSI began to emerge after 1994.

Support for civic-engaged scholarship

If the idea becomes more accepted that civic-engaged scholarship is very similar in structure and form to industry-engaged scholarship, I believe an important conceptual step about so-called 'community engagement' will have been taken. It follows, therefore, that most of the policy initiatives suggested above could also potentially enhance U–CS research work. For example, providing finance and other university support and recognition for Model A-type centres would surely benefit those research groupings seeking to make U–CS central to their research work. A career track for researchers would, similarly, benefit those contract university researchers currently within research centres and units that are working with civil society organisations (like the Sustainability Centre of Case 6). A significant increase in the levels of research funding for the universities will potentially also benefit research work with civil society.

Two qualifications need to be made, however, about the points of similarity of U–CS and U–I research relations. Firstly, what I have perhaps not stressed enough in previous chapters is that if one is talking about 'unlocking the academic knowledge' of the university for (and with) society, one needs to ask questions about who benefits in society, whether the public good will be served and, more generally, whether social justice will be furthered. These are value questions that I believe need to be asked, whether the 'engaged scholarship' is in relation to civil society or to industry. Secondly, as noted particularly in Chapter 3, the majority of low-income people in South Africa do not work within large and medium enterprises (i.e. in industry or government), and are therefore overlooked by our current national policies to enhance the NSI and, implicitly, triple helix U–I–G relations. Thus a vital reason
for enhancing fourth helix or U–CS relations is to link up with the development needs of the majority of poor people who are outside the formal economy, who labour instead in small enterprises or the informal or even survivalist sectors of our economy. Linking up with this other and more hidden marginal economy and society should be a priority for any engaged scholarship linked to U–CS research relations – in needy research areas such as housing or education or transport or informal settlement planning.

Such concerns relating to the ‘university in development’ with civil society, and focused on the questions just mentioned, do however point to issues of academic identity raised in Chapter 6: do academics wish to undertake research work linked to civil society rather than to industry, or perhaps prefer to focus on ‘pure’ research without any linkages to external stakeholders or clients? An interesting approach to this over the past decade has been that of the Community–Campus Partnerships for Health (CCPH 2005) in the USA (mentioned in Chapter 3). Since the 1990s there has been a growing emphasis by the NIH in the USA on what has been termed ‘translational research’ – research at university centres or units that can be translated into practical applications in a clinic or hospital, and moreover bring insights from the application field back into the university laboratory or research centre (Perlstatt 2009). This has dovetailed with the CCPH organisation of university health scholars who have been seeking to establish stronger community–campus linkages in health on American campuses, including those of research-intensive universities. In my view, a very important policy initiative on the part of the CCPH has been an attempt to broaden the criteria for what it calls P&T (promotion and tenure), which it sees as deeply shaping the identity (and hence activities) of American health (and other) academics. In addition to the well-established criteria of peer-reviewed publications underpinning this P&T system, the CCPH has been waging a battle to get other criteria for research included as well: for example, research leading to government and community health reports; research embedded in plans for new health systems; and research resulting in the development of innovations in clinical practices. The CCPH has thus recently developed a toolkit that provides practical procedures and ideas about how health academics might construct their teaching and research portfolios and CVs in order to provide evidence of these forms and products of ‘engaged scholarship’, in addition to standard peer-reviewed publications (Jordan 2007). Furthermore, with regard to the important issue of peer review (is it ‘good’ or ‘poor’ engaged scholarship?), the CCPH has sought to establish a body of senior and experienced ‘engaged health scholars’ who can advise and make recommendations about ‘outputs’ listed in such research portfolios by applicants for P&T.

I would therefore propose that probably the most important policy initiatives aimed at furthering the development of U–CS research work, the fourth helix, and related questions of engaged scholarship, would involve academics within our university taking steps along the lines of the CCPH. In other words, academics, within their universities and probably also within their national disciplinary associations, need to develop toolkits and other allied mechanisms whereby academics in each
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disciplinary field can receive guidance on how to put forward their ‘engaged’ research work as worthy for P&T purposes. It might also be valuable for disciplinary or other academic associations or groups to set up a similar review structure to that of the CCPH – a grouping of senior engaged scholars who can form a ‘committee of review’ for work being proposed as worthy of good engaged scholarship.

I believe that initiatives like the above, which the engaged scholarship movement in the USA has been exploring over the past two decades, will deal much more directly with core issues of academic identity than will other more general calls for conferences and debates about the meaning of community engagement, which seem to be so prevalent currently in South Africa. As for most aspects of the second academic transformation (and the earlier first academic transformation), the taproots lie within the values, structures and rules of university research practices (for centres, units and individuals), and also inside the identity structures of the academics themselves. New concepts and new policies, which genuinely penetrate these inner areas of a university, are much more likely than any other approaches to enhance the ‘unlocking of university knowledge’ for and with society.

Notes
1 See NRF Blue Skies (2010), the website of its ‘Blue Skies Research Programme’, where because of these problems expressed during 2008/09, the NRF has begun national discussions about the ‘meaning’ and ‘role’ of such basic research.
2 See for example some of the discussions in CHE (2010).
3 On this NRF website, such ‘physical or virtual centres’ are described as being a ‘common research funding instrument’ in a range of (cited) countries, which ‘concentrate existing capacity and resources to enable researchers to collaborate across disciplines on long-term projects…’
4 The discussion that follows about the CCPH is derived from the CCPH website (http://depts.washington.edu/ccph/scholarship.html) and also from some interviews that I conducted in the USA during 2009/10 about issues of ‘translational research’.
Appendix 1
Research methodology employed in the study

At the beginning of 2000, funding for the original project that gave rise to this book was obtained from the International Research Development Centre (IDRC), Canada, through the Trade and Industrial Policy Secretariat (TIPS, linked to the Department of Trade and Industry of South Africa), which was supporting various socio-economic research projects at the time. This project – consisting of research into modes of research organisation at Western Cape HEIs – was itself a sub-project of a larger research project, the Western Cape Higher Education Research Project based at the Education Policy Unit of the University of the Western Cape, which included sub-projects focusing on students, academic staff, etc.

In the original proposal in 2000 to the IDRC for this sub-project, entitled 'Unlocking Intellectual Knowledge: Case Studies of Research Centres/Units at Universities and Technikons of the Western Cape', the focus of the research was defined as follows:

To establish what factors enhance and/or inhibit the involvement of research centres and units in ‘applied research’, by addressing questions such as:

- What makes for ‘best practice’ in such research at both the universities and technikons (and whether applied research at these two types differs);
- How the research is organised in relation to stakeholders in industry, and government, and with other organisations where relevant;
- How HEIs might undertake reforms in their research administration structures and practices to enhance applied research;
- How general policies might be constructed by different organisations and at national government level, to enhance forms of applied research by HEIs.

The decision to focus the study on the five HEIs of the Western Cape meant that the research would focus on the following HEIs: the universities of Cape Town, Stellenbosch and the Western Cape; and Cape Technikon and Peninsula Technikon.

Given limited funding and resources, I decided that the above core research questions would best be explored by means of in-depth case studies of 10–15 ‘best practice’, use-oriented research centres and units, spanning the three universities and two technikons of the Western Cape. The basic method employed during the first phase of research, throughout 2000, was to undertake in-depth interviews (usually one, sometimes two) with the director of a centre or unit. In addition, similar additional in-depth interviews were undertaken with two and sometimes more, usually senior, researchers within a respective centre or unit, to explore the same and additional issues as those posed for the director.
It should be noted (as discussed more fully in the Introduction to Part 1) that the initial idea of ‘centres’ and ‘units’ as the focus of investigation began to evolve into a more complex idea of ‘research groupings’ of various types, with an eventual classification of these types into the categories Model A (a ‘real’ centre), Model B (a ‘real’ unit) and Model C (a ‘virtual’ centre).6

Although the form of in-depth interviewing involved a loosely structured interview schedule, which could be varied according to the context and the type of centre or unit, in general the interviews covered the following areas (with terminology as of that time):

- how the centre/unit was initially set up, and how its development evolved over time;
- how the centre/unit was internally structured;
- the composition of personnel, both research and administrative staff;
- the finances of the centre/unit;
- the main clients for applied research, with respect to industry or government or other organisations;
- the mission and orientation of the research centre/unit;
- the major external and internal problems faced by the centre/unit;
- some of the major successes of the centre/unit;
- its role in teaching and other activities allied to the research;
- types of research outputs, including lists of publications of various forms;
- attitudes and practices in relation to forms of applied research;
- attitudes and practices in relation to ‘market-oriented’ research activities;
- issues pertaining to the location of a centre/unit at a university or technikon;
- relationship to major national research agencies;
- relationship to other research centres/units in the Western Cape and elsewhere;
- future plans and anticipated difficulties.

These in-depth interviews generally lasted one to two hours, were almost always tape-recorded and transcribed verbatim (facilitating the extensive use of quotes and mini-stories, as in Part 2 of the book), and were thus purposefully open-ended with respect to the guide questions. In addition, extensive documentary material on each centre or unit was collected during the interview visits (e.g. annual reports, articles and technical reports, brochures); websites of these groupings were visited to obtain additional valuable information, often including the CVs of researchers within a research grouping.

With regard to the method of selecting the case studies, it was initially decided to study more than 10 but fewer than 15 centres/units: this was based on consideration of the available resources (time and finances) and also on consideration of the in-depth nature of the study, including the potential for developing insights of a more general nature with respect to university research centres and units in the Western Cape, and sometimes South Africa as a whole (see Part 3 of the book). Consequently, the aim was to seek to study two to three centres/units from each of the three universities and two centres/units from each of the two technikons.
With this as a sampling framework, early in 2000 each of the five respective senior directors of research administration of the Western Cape universities and technikons was approached, requesting them to put forward two or three or more of what they regarded as ‘best practice research centres or units’, based on the following criteria:7

- that a centre/unit should be undertaking applied research for industry and/or government and also, if possible, for other organisations;
- that a centre/unit should preferably be undertaking applied research at both national and local levels;
- that at least one centre/unit should be undertaking applied research in the natural sciences or engineering, while at least one should be in the area of the social sciences;
- that each centre/unit should voluntarily agree to participate as a case study.

What transpired was that each of the five HEI research directors became enthusiastic about facilitating these case studies and was very keen, moreover, to put forward what were regarded as the ‘best application-oriented’ (my term used in 2000) research centres or units of the respective HEI. Therefore, all of what in Chapters 4 and 5 were eventually defined for analysis as ‘new real centres’ (Cases 1, 6, 7) and ‘new virtual centres’ (Cases 3, 8, 9, 10) were selected in this way by the research directors. However, while some of the smaller units (Cases 2, 4) were also put forward by their directors in this way, I selected two with reference to what might be interesting cases for specific kinds of questions (Cases 0 and 5, with a focus respectively on PBR and on PAR-cum-consultancy work in the field of commerce). The total sample thus eventually made up 11 cases, with four of the cases spread across the two technikons and the other seven spread across the three universities. It should also be mentioned that during the first phase of interviews of 2000, a few additional cases were originally investigated (by means of interviews and documentation), all put forward by the institutions themselves. However, during the second and third phases of the study during early 2005 and early 2007 respectively, these were not followed up on. This was because the initial interviews in 2005 with the additional few proposed cases showed that they were not adding anything unique to the overall analytical framework, which was by then emerging for the study as a whole (see Introduction to Part 1). So it was decided during the fieldwork of early 2005 that it was better to focus intensively on the finally selected 11.

The latter points lead to some further comments about the second phase of the study, completed during the early months of 2005, and the third phase of the study, completed early in 2007. As described in the Introduction to Part 1, I decided in 2004 to embark on further phases of data collection, in other words, to develop a ‘historical sociology’ of the 11 cases for the period 2000–2005–2007. With support and funding from the Knowledge Systems Group of the HSRC in Cape Town, under executive director Professor Michael Kahn, I therefore did follow-up interviews with all 11 research directors and, in a few cases, also with some of their researchers, and collected further documentation on how the respective centres or units had developed over the period up to 2005. This second phase was undertaken during
the summer academic teaching break at the end of 2004. This was followed, in turn, during the summer academic teaching break at the end of 2006, with a third phase to establish trends during the period 2005–07 for each case. Here, too, each director, and in some cases (as described for the relevant cases in Part 2) a few researchers, were again interviewed. It should be noted that, as in the first and second phases, interviews generally spanned one to two hours, thereby facilitating a relatively in-depth form of data collection throughout.

After the final interviews of 2007, the work from 2007–09 concentrated on the analysis of Part 3 (‘Drawing together the threads from the 11 case studies’), and relating this comparative analysis across the cases to the theoretical perspectives of Part 1 and the individual case material of Part 2. Overall, the value of this research methodology should be assessed in terms of its capacity to sustain the threads of analysis throughout the book around the central questions of a second academic transformation and third capitalist industrial revolution; with regard to the specific focus on modes of internal organisation of research groupings within the Western Cape HEIs and the associated factors which were enhancing and/or inhibiting the use-oriented research of the 11 cases.

Notes

1 From a research contract with TIPS/IDRC, January 2000.

2 ‘Western Cape’, for purposes of this study, meant a location in the greater Cape Town area including Stellenbosch.

3 See the Introduction to Part 2 (Table ii.5), where the Cape Technikon falls at number 18 within the ‘Third Group’ (with ‘weak’ research intensity), and the Peninsula Technikon at number 24. After 2003, mergers among the 36 HEIs of the apartheid era began so that, by 2005 – the moment described by Table ii.5 – there were 30 HEIs. However, as discussed in Part 2 in relation to my case studies, the effect of the merger of the Cape Technikon with Peninsula Technikon, which began after 2004, to form the new Cape Peninsula University of Technology, had not yet in any significant way impacted on my four ex-technikon case studies when I undertook the final phase of interviews in early 2007.

4 As discussed in the Introduction to Part 1, in 2000 ‘use-oriented’ research was initially considered as focusing on ‘applied research’; only later, after 2004, did I shift to the perspective of use-oriented research as comprising both UIBR and PAR.

5 During the first phase of the interviews in 2000, I was assisted by the excellent work of two experienced senior researchers, Dr Sharman Wickham and Dr Alexandra Hofmanner, who undertook most of the interviews (occasionally I joined them for an interview, which they directed). With regard to the collection of documents and other source material, they were assisted by a number of other research assistants (see Preface, for names of this group). The second phase (early 2005) and third phase (early 2007) of the interviews were undertaken only by me.

6 During the initial sample selection in 2000, I utilised as a rough guide the NRF definition of research centres and units in use at the time, in which the distinction was essentially based on size – with a centre comprising at least five senior researchers while a unit was
somewhat smaller (NRF 2001: 1–2). As mentioned in the Introduction to Part 1, I ensured in the sampling process that at least one-third of the sample were smaller units, to enable comparison between the two types. See further the Chapter 3 discussion of how, during the analysis phases after 2005, I eventually arrived at a more complex definition of ‘research centre’ and other types of research groupings based on international literature and the case study material itself.

7 The letter also outlined in some detail the core focus of the study (as cited above with respect to the original TIPS/IDRC proposal), and also the type of questions to be asked of each director of the centre or unit (along the lines of the open-ended questions cited above).

8 The exception was the Agriculture Centre (Case 1) where I undertook interviews during mid-2004, because of the need to link my study to data being collected for another study on this agri-sector by two colleagues.
## Appendix 2

### The case studies

Table A2.1 *The case studies: Model type, pseudonym and mode of internal organisation of each case*

<table>
<thead>
<tr>
<th>Model type</th>
<th>Case (as exemplar)</th>
<th>Pseudonym for grouping</th>
<th>Pseudonym for lead professor(s)</th>
<th>Mode of internal organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chapter 4</td>
<td>Model T</td>
<td>Case 0</td>
<td>Science (Virtual) Unit</td>
<td>traditional (virtual) unit</td>
</tr>
<tr>
<td></td>
<td>Model A</td>
<td>Case 1</td>
<td>Agriculture Centre</td>
<td>new (real) centre</td>
</tr>
<tr>
<td></td>
<td>Model B</td>
<td>Case 2</td>
<td>Genes Unit</td>
<td>new (real) unit</td>
</tr>
<tr>
<td></td>
<td>Model C</td>
<td>Case 3</td>
<td>Space (Virtual) Centre</td>
<td>new (virtual) centre</td>
</tr>
<tr>
<td>Chapter 5</td>
<td>In between Model T &amp; Model B</td>
<td>Case 4</td>
<td>Biogenetics Unit</td>
<td>Prof. Biogenetics</td>
</tr>
<tr>
<td></td>
<td>In between Model T &amp; Model B</td>
<td>Case 5</td>
<td>Commerce Unit</td>
<td>Prof. Commerce</td>
</tr>
<tr>
<td></td>
<td>In between Model T &amp; Model A</td>
<td>Case 6</td>
<td>Sustainability Centre</td>
<td>Prof. Sustain</td>
</tr>
<tr>
<td></td>
<td>In between Model T &amp; Model A</td>
<td>Case 7</td>
<td>Fluids Centre</td>
<td>Prof. Fluids</td>
</tr>
<tr>
<td></td>
<td>In between Model T &amp; Model C</td>
<td>Case 8</td>
<td>(Virtual) Centre-as-Department</td>
<td>Profs in the Centre-as-Department</td>
</tr>
<tr>
<td></td>
<td>In between Model T &amp; Model C</td>
<td>Case 9</td>
<td>(Virtual) Centre-in-a-Faculty</td>
<td>Profs in the Centre-in-a-Faculty</td>
</tr>
<tr>
<td></td>
<td>In between Model T &amp; Model C</td>
<td>Case 10</td>
<td>(Virtual) Centre-as-Agglomeration</td>
<td>Profs in the Centre-as-Agglomeration</td>
</tr>
</tbody>
</table>
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