Science, Engineering and Technology Research Funding Policy in Ireland 1995-2008: A Policy Document Analysis

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Abstract

In the period 1995 to 2008 there has been an increased level of government funding for research and development in higher education institutions in Ireland.

This thesis analyses the evolving theoretical literature on the production of knowledge, and traces how models of research and innovation have evolved in the contemporary period. Four models are discussed: (i) linear model, (ii) national systems of innovation, (iii) mode-2 science, and (iv) triple helix.

The thesis presents a detailed analysis of a series of public documents produced in Ireland in the period, and discusses how each one relates to the theoretical background. Some of these relationships are explicit, where documents cite key authors and the models as discussed in the theoretical literature. Some of the relationships are implicit, where the manner in which the process of research and development is described implies that certain models are being assumed.

The thesis subsequently discusses the results of this analysis, where it seems that the Irish policy literature is moving away from an engagement with at least some of these theoretical models, towards a very operationalised implementation strategy. This is epitomised by the development of the Strategy for Science Technology and Innovation.

The thesis finally makes a number of recommendations for policy makers, advising the more detailed study and analysis of Ireland's own national system of innovation, and the prioritisation of the use of research funding to build up capabilities in identified areas of this system that are weak.

Chapter 1

Introduction

In the late twentieth century and early twenty-first century, Higher Education Institutions (HEIs) are being faced with unprecedented pressure to change and adapt to new demands. One of the main factors applying this pressure is the changing nature of funding mechanisms that now put much more emphasis on winning competitive research funding, particularly in the areas of Science, Engineering and Technology (SET) where the larger research funding awards are usually available. The tendency is for the income from these activities to become increasingly more significant for the HEIs, forcing them to decide whether to prioritise winning such funding in strategic research agendas, recruitment strategies, and other mechanisms. Often the justification for this shift in the government's funding of the HEIs is based on arguments about the need for HEIs to respond to the needs of the *knowledge economy*, or more generally the *knowledge society*. Often the HEIs, and the traditional universities in particular, respond with a defence that cites the need for academic basic research (fundamental, basic or blue skies) to operate without direct interference from industrial or societal needs — the academics need space to think and explore their curiosity. Thus the debate about the increasing accountability of HEIs is often framed as a debate both about how research should be funded, and about the nature of R&D itself. It is often hard to disentangle the two types of argument.

In most of the debate on higher education institutions, authors simply refer to universities rather than HEIs. Thus the debate is often framed as one about the future of universities, or the challenges faced by universities alone. Another term sometimes used is *third level*, meaning education post-secondary school; in Ireland the additional term *fourth level* is often used to refer to post-graduate teaching and research. In this thesis the term university can be assumed to refer to all HEIs, unless a specific discussion is being conducted about the different types of institutions in the higher education system.

This thesis is focused on one particular part of this debate. It addresses the policy informing investment in publicly funded Science, Engineering & Technology (SET) research in HEIs in Ireland in the period 1995–2008. The story of this period for Ireland was largely one of unprecedented economic growth, a period known as the *Celtic Tiger*, and the huge increase in investment in publicly funded research in HEIs, from the late 1990s onwards. However, from the end of 2008 this dramatic economic growth in Ireland has stalled. This change is seen to be as a consequence of both a world economic downturn triggered by an international banking crisis, and of an unrelated, but inter-twined, bursting of a property bubble in Ireland. The impact on the Irish public finances has been catastrophic, as the income linked to property taxes has collapsed, and the number of people claiming unemployment benefits has increased. There is now a vigorous national debate in Ireland about all forms of public funding, and Ireland has been the first country in the Eurozone to cut pay for its public sector in 2009, in order to try and regain control of its public expenditure, and balance the books. So now more than ever the funding policy needs to be very clear about why public monies should be invested in research in HEIs, and what explicit expectations exist on the potential return on that investment, however indirect. Therefore this thesis makes a direct contribution to this debate, justifying such investment but only if it addresses the complex nature of the national innovation system in the country, and not just selected parts of that ecosystem. So the economic context that frames the time period for the thesis focus increases its potential relevance to an emerging national debate.

The thesis explores the complex theoretical models for how research and innovation, and thus industrial impact, are linked, and argues that much policy is still based on older naïve perspectives that assume a linear model linking pure academically-focused basic research, applied research, and commercialisation activities. These older models date back to the post-war period. Newer models that have emerged in the late 1980s and 1990s that seriously challenge the linear model. This thesis primary methodology is to look for evidence of these models in the Irish research funding policy literature. The discussion and conclusions relate to potential future policy directions that consciously embrace the more complex non-linear models, and thus encourage a balance of research and development activity in a spectrum between pure basic and commercially-focused exploitation activities. Harmonising incentives across this spectrum is not easy, and certainly is not helped by competing agencies responsible for different sections of the spectrum, and non-aligned approaches taken by such agencies.

1.1 What Has the University Become?

Putting debates on the purpose of HEIs back into a larger context, in the Anglo-American world (US, Canada, UK, Ireland, Australia, and New Zealand) there seems to have been a need to re-evaluate the role of the university itself, almost a millennial urge around the turn of the century. One early US example was Derek Bok's analysis, as President of Harvard, of the modern role of a university [Bok, 1982]. His series of essays focused on the need for academia to address society with a socially responsible set of responses, and its failure to do so adequately to date. Bok's more recent contribution to the debate on re-positioning the university has been to warn of increasing commercialisation in US universities [Bok, 2003].

In the UK and Ireland perhaps the most definitive account of what constitutes the role of a university has been Newman's *The Idea of a University* [Newman, 1854]. Two books published in the last ten years have explicitly re-addressed this vision for the first time in a century and a half. In the first of these, Maskell and Robinson have been prompted by the shift in UK policy to defend what they view as the traditional Newman view of a liberal education [Maskell and Robinson, 2001], critiquing the uneducated nature of the policy discussion informing the transformations that are taking place in higher education. They question the language of investment in higher education and its explicit link to economic aims and objectives that they claim typifies current policy in the UK. In the second of these Gordon Graham takes a more nuanced approach [Graham, 2008], discussing the tensions between traditional liberal education views and modernising views of various forms, balancing his analysis between these two poles.

In Australia Marginson and Considine trace the emerging enterprise culture in Australian universities during the 1990s [Marginson and Considine, 2000]. Their analysis pivots on the fact that public underfunding of the sector is driving a pseudo-market in alternative income streams.

One particularly influential articulation of this process of change in universities is Slaughter and Leslie's *academic capitalism* [Slaughter and Leslie, 1999]. The authors chart the fundamental change in the nature of the work being carried out by academics, and the way that HEIs are governed, in the USA, UK, Australia and Canada. They claim that the current rate of change has not been seen in universities since the late nineteenth century, then in response to the industrial revolution. In all these countries there is evidence that the traditional block grant for universities has been frozen or is declining, and that new funding is channeled through competitive processes usually linked to research and development, coming either directly from industry, or from government with a policy of encouraging industrial linkages. Slaughter et al. link this rise of academic capitalism to the new managerialism in the management of the institutions.

In a comprehensive analysis of the research in the US through the 1980s and

1990s Geiger traces the complex story of the use of the marketplace to influence higher education funding and priorities [Geiger, 2004]. His analysis of four spheres of activity in contemporary American universities—finances, undergraduates, research and relations with industry—is at pains to highlight the extent to which simplistic economic models that hold true for commercial companies do not apply to the higher education sector. However, he acknowledges the extent to which the metaphor of the marketplace is central to the changes that have taken place in these spheres over the past two decades.

Another articulation is based on viewing this process within the context of globalization. Etzkowitz and Leydesdorff describe this as the creation of a global knowledge economy, and the evolution of a complex ecosystem of interrelationships that they describe as the *triple helix* of university, industry and government linkages [Etzkowitz and Leydesdorff, 1997]. This is one of the theoretical models discussed in more detail in Chapter 4.

An influential view of this process is based on an analysis of the changing nature of the process of knowledge production itself. Gibbons, Limoges, Nowotny, Schwartzman, Scott and Trow argue that, in some cases, the nature of academic enquiry is changing so that traditional discipline-based Mode-1 science is giving way to a new trans-disciplinary *Mode-2 science*, where groups of experts from different disciplines form a new temporary discipline for the duration of a collaboration [Gibbons et al., 1994]. If this thesis has validity, it poses very fundamental threats to the nature of universities, structured and governed as they are on disciplinary-based faculties and departments. This is another of the theoretical models discussed in more detail in Chapter 4.

Arguably, an important factor in these changes is based purely on the pressure for HEIs to process ever greater numbers of both undergraduate and postgraduate students — the pressures of expansion. In this sense what is happening is a side-effect, as Trow (one of the Mode-2 authors) has previously argued over thirty years ago, of the shift from elite education, through mass education, towards universal education in the higher education sector. A similar shift has previously occurred in the primary and secondary education sectors [Trow, 1974]. More recently Trow updated this analysis, commenting on its relevance over the intervening period [Trow, 2005]. Obviously, requiring greater numbers of students increases the costs of running the higher education sector, and this typically precipitates some form of funding crisis that is often resolved with some combination of student fees, and an emphasis on universities raising funding from other sources than the government block grant based on student full time equivalents (FTEs).

1.2 Universities and the Economy

Alternative economic views of the challenges facing the higher education system place more emphasis on its economic role within a National System of Innovation (NSI) [Nelson, 1993]. The concept is that only by analysing the set of institutions in a country whose interactions determine the innovative performance in national companies can one understand the systems — where innovation is about learning and putting into practice new product designs and manufacturing processes that are novel to those companies. Higher education institutions, and R&D activity in particular, are seen as one of the key elements of such systems. Whilst it is true that many industrial technology innovations happen before the science is understood, and indeed sometimes found new sciences exploring their implications (e.g. thermodynamics explored the science behind the steam age after it had already transformed the world industrially), often the idea flow is the other way with new scientific discoveries leading to various forms of commercial exploitation. In either case, in the twentieth century the majority of academic and industrial discoveries are made by people with some form of university training in science and engineering, so universities are part of the system whether as a training ground for the key individuals, or as a place for the new knowledge to be formed. The NSI view is a further theoretical model discussed in more detail in Chapter 4.

The wider economic context for the late twentieth and early twenty-first century is that of globalisation, and of the emergence of the *knowledge economy* as a metaphor for this development, or in a wider societal context the *knowledge society*. A combination of comparative political stability in many areas of the world, and of the acceptance of free market capitalism with lowered trade barriers as a system for wealth creation, has defined the context for globalisation. This combined with the development of new technologies that make working across long distances more feasible, both in terms of affordable transport and in terms of communications technologies, has led to an emerging global economy where large multi-national companies locate different elements of their operations in locations best suited to those operations. HEIs are not immune to these developments. It is within this context that national, and to an extent regional, policy makers have tried to tie in the HEIs to systems of innovation to allow national economies to benefit from the new knowledge produced in the HEIs.

The arguments about the economic value of all aspects of education are an intrinsic part of the education debate. Arguably all parts of the education system have been heavily influenced by utilitarian arguments about the economic value of having a better educated workforce. The educational establishment has traditionally rejected this narrow justification for education, arguing for the wider role of educating citizens for society and thus allowing students to achieve their own potential. One contemporary airing of this debate is Alison Wolf's *Does*

Education Matter? Myths about education and economic growth [Wolf, 2002]. She rehearses these arguments, and addresses university level education in two of the eight chapters, mainly dealing with the massification of the third level and the concomitant pressures upon the system. Her conclusion is that governments have had a naïve view of the education system in terms of linking educational expenditure to growth.

> "But does education matter in the ways in which governments the world over believe that it does? And are these governments' education policies accordingly well conceived? To those questions the answer must be 'No'. As this book has documented, two naïve beliefs have a distorting influence: the belief in a simple, direct relationship between the amount of education in a society and its future economic growth rate, and the belief that governments can fine-tune education expenditures to maximize that self-same rate of growth. Neither is correct."
> [Wolf, 2002, p. 244]

However, when one focuses this debate on the research and development carried out in universities and other higher education institutions, even though there is still an important element of education and training, i.e. the training of research students, the argument shifts away from a dichotomy between those who favour broad-based liberal education for its own sake versus those who see a real utilitarian value in appropriate training. Instead the argument shifts towards the issue of how the ideas created in these institutions filter into the economic system, how they are commercialised, and thus how the university is a part of the wider research and innovation system. So, we can conclude that it is in the area of research and development funding that there is the greatest expectation of a more direct link between the academy and industry. Indeed one could argue in a similar vein for the impact of the academy upon society more generally, in the sense that it impacts positively upon culture and bears other benefits for society; it could be further argued that it is in the research students, and in the joint research and scholastic activity of its staff and students, that these other benefits are also generated, and thus that the impact derives more from the research than from the teaching at degree level.

This poses an interesting argument, in that it highlights the fact that, unlike the primary, secondary and tertiary education systems, research and development, or the "fourth level" as it is called in Ireland, is not fully focused on the student. Instead there is a focus on research activities, often staffed by a combination of faculty, full-time research staff — most typically post-doctoral research fellows, but also research assistants and other types of research staff who may

not have doctoral level qualifications — and that this is quite unique in the education system. Personal experience indicates that it is common to have some debate with funding agencies about the suitable ratio of postdoctoral researchers to postgraduate students funded by research funding programmes — the more research-output oriented the funding the lower the requirement for high numbers of students; the more student-metric focused the funding the greater the requirement for high numbers of students. Thus on many funded research programmes it is common for the postdoctoral researchers (funded staff) to outnumber the research students (funded students). In no other area of education do the staff outnumber the students. However, one could view this as a continuum of research process education and training through research students towards junior post-doctoral researchers who are all learning about the research process through engagement in research activities in larger teams, so that the boundary between student and staff is blurred. Conversely the research students are often given responsibilities that treat them more like staff than students, and in some countries' systems these students may have both a staff contract for the grant award and full-time student status. The issue of large teams of research staff who are not students is more particularly relevant to the resource intensive science and engineering research activities than to social science and humanities research and scholarship, where individuality may still be the norm in research. But even here an active researcher may be a member of faculty who engages very actively in research, but has no students. Therefore it is the case that the research area of the education system is the one area that cannot claim to fully focus upon students.

However, despite this, one could also see some merit in the argument that many of the tensions around the area of research in HEIs relates to the massification of the research student process, and the pressures that this brings to bear on what has traditionally been, particularly in the UK and Ireland, the least formalised part of the education process. The pressures seek to formalise structures to deal with increased numbers, and to create graduate schools where a mixture of formally delivered core materials augments a looser supervisor-student relationship to manage the research process over 3 to 5 years. So although students are not necessarily core to everything that research and development in HEIs is about, they are still a significant part of the process in many cases. Indeed counting the number of PhD graduates in a discipline has become one of the most important metrics for research activity in research centres, in departments and schools, in institutions, by research funding agencies (in particular those focused on basic research such as research councils), and nationally. As is the case at all levels of education, the arguments brought on by massification often tend towards discussion on the dilution of the quality of current students compared with

previous students.

1.3 Higher Education Institutions in Ireland — Thesis Focus

In some senses Ireland has trailed the US and the UK in terms of the pressures on its HEIs. Traditionally Ireland's HEIs had a very strong teaching focus with small sums of funding available for research compared with the UK and the US, and no large defence budgets to invest in engineering and technology research. The main function economically of the HEI sector (comprising universities and institutes of technology) was to produce skilled workers required by the foreign companies located in Ireland as part of its foreign direct investment (FDI) strategy from the 1960s to the 1990s. The remarkable success of the Irish HEI sector has been to maintain a very high reputation in terms of the quality of its graduates, despite receiving much less funding than US or UK institutions. However, it is hard to find clear evidence of the quality of the Irish education system, other than the argument that the levels of FDI investment were based, in no small measure, on a perception by US multinationals of a well educated workforce, and that the performance of the manufacturing centres established seemed to validate this. The more cynical could argue that these companies (e.g. Intel, Dell, IBM, Wyeth, Janssen Pharmaceutical, Boston Scientific, HP, Xerox — each employing over 2,000 in 2005) were happy to keep praising the Irish education system as long as they were supported by the Irish Development Agency (IDA) and by generous tax incentives. Ireland ranked 5th in the IMD World Competitiveness Yearbook in 2000, it ranked 19th in 2009 — the quality of the education system in terms of providing a suitably skilled workforce is an important part of this ranking system [Garelli, 2009].

A research culture developed based upon individual research activity and upon winning small scale research success via external funding such as the EU framework programmes and the Welcome Trust. In the period analysed in this thesis the situation in Ireland changed radically. From the mid-1990s to the present successive Irish governments made the decision to invest heavily in R&D, particularly in HEIs. This has created a new dynamic of competition between the Irish HEIs for these large competitive research programmes, that provide recurrent funding for large numbers of contract research staff/students and even larger capital funding for buildings and large scale equipment installations.

This thesis is focused on developing an understanding of how the SET research and development policy has developed in Ireland in the period between the mid 1990s and 2008. This policy is linked both to the educational policy for the higher education institutions in Ireland, and to the innovation policy aimed at promoting dynamic links between the HEIs and industry in order to promote

the *knowledge economy* specifically, and the *knowledge society* more generally. It is within this period that the successive governments have radically overhauled the funding mechanisms for research and development, and has committed considerable additional funding, so much so that where Ireland was languishing at the bottom of any league table of R&D funding prior to the late 1990s, it is now climbing rapidly up these tables.

This thesis argues that there has been a strong trend in Irish science policy towards aligning its *SET* and *Science, Technology & Innovation (STI)* policies, often referred to simply as a *Science Policy*, with larger external influences, such as the OECD and the EU. In some ways aligning with the USA has been important economically because of the predominance of US Foreign Direct Investment (FDI) as a force in the Irish economy. There are questions over whether a policy that works in such a large economy as the US is appropriate for a country of Ireland's size. The discussions of the theoretical framework in Chapter 4 and of the terminology in Chapter 2 both show evidence for a strong link between the dominant language coming from post-war US science policy, most famously expressed by Bush in *Science: The Endless Frontier* [Bush, 1945], through the OECD *Frascati Manuals* (e.g. [OECD, 1963]), and in nature of the statistics gathered by all OECD countries and thus the metrics used to measure R&D investment.

The argument in this thesis is that such language, either implicitly or explicitly, supports a very narrow linear model of innovation that assumes that innovation is enabled by basic research investment in universities, and applied research investment in industry-academic linkages, and then in various forms of commercial exploitation and uptake. The economic reality may be somewhat different, and the reason why the traditional linear model is supported may often lie more in universities' desire to stake out an area, i.e. basic research rather than applied research, where there are fewer limitations and less control from government or industry, whilst still encouraging large state investment. So it may be necessary to more evenly balance the research funding incentives across the full range of the research and development spectrum from basic research through applied research to commercialisation. Recognition of the complexity of this ecosystem, and an development of an understanding of how best to nurture all aspects of the system, is necessary.

It is worth being clear at the outset what limits there are to the scope of the work carried out. This thesis

- is focused on the research and development activities in HEIs rather than on the wider educational and cultural role of universities or other HEIs;

- is focused on the area of SET rather than on research and development in all disciplines;

- is focused on the country of Ireland, rather than on other international examples;
- is focused on the core period 1995–2008;
- is focused on the justifications expressed in policy documents for the increased investment in research and development in SET in the higher education sector in this period;
- explores the theoretical models that justify such an investment in research and development, juxtaposing the traditional linear model with a number of other models that are all explicitly non-linear;
- looks for evidence of the use of these theoretical models to justify research and development investment in Ireland in SET in the period.

This thesis is structured around a detailed analysis of a series of public documents, that could loosely be termed policy documents. The core work of the thesis is presented in the two penultimate chapters: Chapter 6 1995–2000 that deals with the policy formation period, where people lobbied for an increase in research funding, and Chapter 7 2001–2008 that deals with the operational implementation of this new research funding in Ireland.

The preceding chapters in the thesis provide and justify the framework for this analysis:

- Chapter 2 describes the research questions and analyses the terminology used to frame these questions and scope the domain, an essential element when the terminology is contested;
- Chapter 3 describes the research funding ecosystem in Ireland by describing each of the institutions involved, and giving a brief political history of the time period;
- Chapter 4 provides a theoretical analysis of the different ways of thinking about research and innovation, looking at the world literature primarily in the domains of social science, education and economics, identifying a number of theoretical models that might be used to understand how research and innovation are linked;
- Chapter 5 describes the methodology used in the textual analysis, emphasising the search for evidence of direct and indirect reference to certain theoretical models, and to the overall theme of increasing contextualisation, placing HEIs within societal and industrial contexts.

Finally, Chapter 8 provides a synthesis of the arguments and the results as well as offering some conclusions.

Chapter 2

A Framework for the Research Questions

2.1 Introduction

This thesis carries out an analysis of Irish research funding policy documents, specifically those targeting Science, Engineering & Technology (SET). The thesis tries to probe what lies beneath the high level, potentially purely rhetorical, adherence by Ireland to the European Union's Lisbon Agenda [EU Commission, 2000]. The Lisbon Agenda was drawn up and adopted in Spring 2000 to underpin the growth, innovation and employment performance of the European Union whilst fostering the inclusiveness of its social models. The Lisbon Agenda explicitly sets a target for all EU countries to increase R&D expenditure to 3% of GDP by 2010, and uses language relating this increase to the potential economic benefits by fostering a knowledge economy in Europe.

The analysis is carried out taking account of, and trying to articulate, the wider academic, social and political framework that the research policy agencies, the research funding agencies, and the agencies funded by the research operate within.

The core research question, described in greater detail in Section 2.5, is:

> *Is there evidence in the development of Irish research funding policy for a contextualisation of science, engineering and technology?*

This chapter helps to elaborate on the terminologies involved in framing this question, and re-phrases this question in various ways. The contextualisation here refers to an erosion of the view that Science, Engineering & Technology (SET) is unconnected to or apart from society, able to gain its own validity within a pure academic context, to one where it is intrinsically linked in various ways to society, and in the case of SET to industry in particular. For shorthand this is referred to as the "contextualisation of SET" and is a key concept within

the thesis. The main aspects of society that are directly relevant to SET research funding are: the government departments and agencies that help fund R&D (here an economic context is paramount—justifying the funding with some return); the industrial context where the results may be applied (here also an economic context is paramount—linking academic research to industry); and the general societal context where the outputs may help improve the standard of living for everyone (here a more general context dominates). So the contextualisation is framed by stakeholders holding the SET community to task as to how their activities link to societal issues outside of the academic endeavour itself.

Thus, this chapter is a first step in outlining the context, a probing of the semantics of the terminology used in this field. That is the primary aim of this chapter. To this end, this chapter outlines the main focus of the thesis, addressing the definitions of key terminology and highlighting the linguistic framework within which the thesis itself can develop. Probing meanings is essentially about questioning assumptions, and this leads to the framing of the research question itself.

This chapter is balanced by the following two chapters:

- Chapter 3 *Contextual Framework* describes in detail the makeup of the Irish innovation system and how it operates;
- Chapter 4 *Theoretical Framework* examines theoretical models for understanding how a national innovation system works.

The overall thesis then draws these three scoping and contextual strands together in a detailed analysis of a core set of Irish policy documents in Chapter 6 and Chapter 7.

2.2 Defining the Domain

The focus of this thesis is on research funding in SET, though often the term used today for this is Science, Technology & Innovation (STI). This section looks at these two broad umbrella terms and explores the definitions of the terminology for the domain.

2.2.1 SET (Science, Engineering & Technology)

In modern intellectual and academic parlance, especially in the social sciences, the concept of science itself is seen as a disputed term. Various heated exchanges on these issues, especially during the 1990s, have been termed the 'science wars'.

In contrast, within the core disciplines that make up natural science (perhaps physics is best regarded as the central discipline), and within the wider

general public in the western world, the term is less disputed and assumed to be coherent philosophically and useful as the primary mechanism for generating new knowledge in modern societies (sometimes contrasted with earlier religious orthodoxies that arguably stifled innovation). At the core of the concept of science is a systematic methodology for understanding of the natural world. The scientific revolution, occurring from the sixteenth century onwards, changed the fundamental mind-set of those affected, typically Europeans and their colonists. If Europe could be said to have a common culture, the shared experience of this revolution would certainly be an important part of it. The initial ideas came from many scientists who had new ideas and models, who built new instruments, and who carried out experiments. Perhaps the most famous of these were: Copernicus (1473-1543), who argued for the heliocentric theory of the solar system; Tycho Brahe (1546-1601) who made extensive and more accurate naked eye observations of the planets; Sir Francis Bacon (1561-1626), who advanced inductive reasoning, proceeding from observation and experimentation; Galileo Galilei (1564-1642) who improved the telescope and made important astronomical observations such as the phases of Venus and the moons of Jupiter; Kepler (1571-1630) who established his three laws of planetary motion; Descartes (1596-1650) who pioneered deductive reasoning, publishing in 1637 *Discourse on Method* [Descartes, 1637]; and Sir Isaac Newton (1642-1727) who built upon the work of Kepler and Galileo and developed calculus. Science today inherits from the tradition of these thinkers who helped reshape our view of the world. Most definitions of modern science derive from concepts established in this period, but the modern scientific structure is often thought to have been formalised institutionally in the nineteenth century, including the modern conception of a university. Ireland has had its own prominent scientists, including Robert Boyle (1627–1691) who is regarded as the first modern chemist, William Rowan Hamilton (1805–1865) who helped establish the wave theory of light, and George Boole (1815–1864) who established the mathematics that modern Computer Science is based upon; although the Irish may be seen to emphasise other aspects cultural heritage, Ireland does have a rich scientific tradition.

In terms of a complete philosophical definition of science, this has continued to be an uncertain area, with the twentieth century philosopher Karl Popper's (1902-1984) theory of falsification, being held up as the most well defined defence of the scientific method [Popper, 1963], though much disputed. Regardless of these philosophical disputes, it is clear that scientists try to explain the world using models that make predictions that can subsequently be tested in experiments. The simplest models that successfully predict what is observed then become accepted as the current theories. For this to work scientists must publish not only their results, but the detail of their experiments, so that others may

repeat the same experiments and either support or refute their results. Thus the publications process, and the peer-review process that is part of this, is one of the fundamental pillars of modern science.

Ziman argues that the philosophical underpinnings of science are shifting. That this is happening in the absence of a full awareness of this by practitioners because "the epistemology of science is linked to its sociology primarily at the level of research practice" [Ziman, 2000, p. 67]. He terms his conception of science *Real Science*, and has based it on a recognition that the post-modern critics of science have indeed undermined the simplistic philosophical foundations of science, but that there still remains a valid social process in science that should be studied and understood and supported. In this he tries to reconcile the science wars. It is not within the scope in this thesis to reconcile this debate, so this thesis defers to Ziman's as the most mature espousal of a potential common ground between practicing scientists, and social science critiques of empiricism as a philosophy, as it paves the way for continued rigorous enquiry, whilst allowing for skepticism about the results.

It is interesting that neither engineering nor technology use the scientific method in exactly the same way as science itself, though they are usually "lumped together" with science; for example when differentiating between science-oriented faculties and humanities faculties in a university. Instead they both take results from science, or sometimes push ahead into areas where no scientific theory yet exists, and then use the scientific information to try and build things that work. So materials science may provide detailed information about a new compound, and then this compound can be used to build a new thing, or an existing thing better or more cheaply. The classic example of engineering and technology leading science is the steam engine. Engineers built and ran steam engines long before a satisfactory theory explaining how the process worked was developed. Arguably, though scientists and engineers may both make extensive use of mathematical models, the engineers are much more pragmatic. They generally want a model that helps them do a task, not necessarily one that explains everything about the phenomenon.

Technology is a recent term, it was first introduced by the Bostonian Jacob Bigelow in 1826, and was most famously used in the name of Massachusetts Institute of Technology (MIT) founded near Boston in 1862 (cited by [Nowotny, 2006, p. 8]). Arguably it is the oldest concept. It is essentially the relationship any society has with its tools that allows it to manage its environment. Thus it is bound up with the concept of what separates human beings from other animals, although minimal tool use has been found among some other species. The way the term is used popularly often equates it with very modern electronic tools, but in its pure definition technology applies equally to the methodology for smelting

bronze as to the mobile telephone. The knowledge of how certain tools can be used is one of the core elements of culture; for example, many histories emphasise the technologies of weapons use, and the impact these had on the dominant cultures in various regions. Thus society is enabled by technology, and certain types of technology can have a dramatic impact on society.

In conclusion, although the term Science, Engineering & Technology is in common, relatively undisputed use, the term hides a complex philosophical paradox in that in reality only one of these areas is scientific in its strictest sense. Science is the formal process of investigating the natural world. Engineering is the pragmatic design and building of tools and systems to exploit the natural world. Technology is the consequence of these two processes; often the term technology is used to encompass all engineering products. Thus the three terms are commonly grouped together, particularly in the names of national and international research councils with responsibility for awarding research student scholarships (e.g. the IRCSET in Ireland is the Irish Research Council for Science, Engineering & Technology). In most countries the academic disciplines that come under the SET umbrella are at the core of the research policies, receiving the largest proportion of research funding, arguably because they have the perceived potential to provide the most economic impact. Strangely much more emphasis seems to be placed on science than on engineering or technology, and there is an implicit assumption that all three share a common epistemology, perhaps because of naïve linear models of the innovation process as discussed further in Chapter 4.

2.2.2 STI (Science, Technology & Innovation)

The grouping together of Science, Technology & Innovation (STI)[1] is a more recent phenomenon. The interesting thing for STI is the assumption that it is possible to link new fundamental ideas about our understanding of the world (through science), to the application of these ideas to particular useful tasks (through technology) and thus to the creation of new tools and new products (innovation).

The grouping is reflected in a new joint Organisation for Economic Co-operation and Development (OECD) and Eurostat (the statistical agency of the EU) publication, the Oslo Manual, that outlines guidelines for collecting data about science, technology and innovation, developed through two editions in the 1990s and now with a third edition [OECD/Eurostat, 2005]. This parallels the traditional OECD

[1]This thesis has its core question framed in terms of SET, but much of the policy literature has adopted STI as the core term. Thus both terms are used throughout this thesis. The analysis draws issues back to the core research question relating to funding for Science, Engineering and Technology (SET) in Ireland's Higher Level Institutions (HEIs).

emphasis on gathering data on investment in research and development, as outlined in the various editions of the Frascati Manual since 1963 [OECD, 1963] now in its sixth edition [OECD, 2002]. The next section in this chapter, dealing with definitions of research, analyses the evolution of the OECD Frascati definitions of research and development through this period. It should be noted that Ireland was a founder member of the OECD in 1960, and has been a member of the European Union (EU) since 1973.

Even though it is not within the remit of this thesis to examine and prove the point, it is fairly self-evident that Irish polices have been very influenced by OECD processes in terms of forming its enterprise and education policies, with the STI policy crossing both. Arguably these OECD processes have defined a world consensus on a range of policy issues that are accepted by many countries (USA, UK, Germany, France, Italy, ...), and are potentially imposed upon others, such as certain developing countries, through the use of World Bank and international aid and other funding incentives. Only the United Nations (UN) could be argued to have more influence than the OECD in terms of a world consensus on these issues.

A review of STI studies in Europe [Wouters et al., 1999] was published recently, and was based on a study conducted with funding from the EU in the late 1990s. This indicates a widespread adoption of the term STI by a range of centres listed in the report, and the fusing of a number of disciplinary strands to create an interesting new focus:

> "It is a relatively young enterprise, the oldest centres just celebrated their thirthieth [sic] anniversary. Perhaps one of its strongest points is its multi- and interdisciplinary character. Born partly out of concern about the consequences of the natural sciences for society, and partly out of a critique of the blind spot of traditional economic and social sciences with respect to innovation and technology, the fields of science, technology, and innovation studies have attracted people from a large number of disciplines. The diverse communities of science and innovation students comprise physicists, philosophers, medical researchers, engineers, chemists, sociologists, anthropologists, linguists, mathematicians, historians, biologists, communications specialists as well as students of popular culture. Virtually all centres in this guide attest to this multifaceted atmosphere."
> [Wouters et al., 1999, pp. 3–4]

Nowotny [Nowotny, 2006] makes the case for innovation as the latest term linking science and society, serving a similar purpose conceptually in the early 21st century as the term technology did in the 19th century (when the term technology

was introduced). It is interesting that we seem to need these more abstract cultural terms to link the outcomes of the scientific process to their impacts on society, and that these terms are often used to frame an overall societal concept of progress, linked to the idea of modernism (and indeed post-modernism). Thus there has been a large body of literature challenging the simplistic assumptions of technological determinism, the use of assumed inevitable technological progress that creates social change; the critics argue that key stakeholders with power can in fact steer the technological change in their direction (for example, in the 19th century much money could have been invested in individualised power generation rather than in centralised power generation), and that technology actually offers choices, but only to those with the power to make an impact. Arguably similar things are now happening with the term innovation, though it is slightly harder to critique than technological determinism. Social scientific analysis apart, there is of course much evidence for technological progress and for innovation in the 19th, 20th and early 21st centuries: canals, railways, electricity, telegraph, telephone, radio, combustion engine, cars, jets, medical advancements, computers, mobile phones and so on. An interesting footnote is that one of the key Irish daily newspapers, *The Irish Times*, started a monthly magazine *Innovation* in June 2007, in which academic research, industrial research, state policies and general business and entrepreneurial issues share the limelight.

There seems to be an emerging trend of formal study of the various elements that enable innovations in the economic system, and of attempts by national governments and wider regional governance entities (such as the EU) to offer incentives for the potentially economically productive linkages across the STI spectrum, particularly through research funding.

2.3 Defining Research

When discussing SET research policy one is faced with an interesting situation. What starts off as a seemingly relatively well defined problem space quickly disintegrates into a morass of ambiguity and analogy. It is interesting that there has been some debate on the meaning of the term 'basic research' to researchers and to policy makers [Calvert, 2002, 2004]. Calvert analysed the definitions used by researchers (in physics and biology) and policy makers in the US and the UK and concluded that the majority used a definition that included an epistemological element (e.g. the type of knowledge produced by basic research is fundamental) and an intentional element (e.g. basic research is curiosity driven rather than needs driven). The next most popular element of definitions used was the distance from the potential application (e.g. basic research results may take many years to be used in application, if they are used at all). Calvert's conclusion, was

that, although the term was somewhat nebulous, it served a useful function for the communities using it, "It is this degree of constructive ambiguity that makes it useful—but also political. The term is therefore more than just a label. It performs social functions—such as protecting autonomy and defining self-image" [Calvert, 2004, p. 266].

2.3.1 Bush's Legacy and Pasteur's Quadrant

The work of Stokes [Stokes, 1997] on *Pasteur's Quadrant: Basic Science and Technological Innovation* has had a considerable influence on policy, especially in the USA. This book traces the origins of the schism between basic research and applied research back to the US policy for funding science in the postwar period that resulted from Vannevar Bush's report to President Roosevelt [Bush, 1945] *Science: The Endless Frontier*. This was published immediately after World War II, and addressed the issue of how scientific research should be funded in the postwar period. Bush's terminology separating basic research (government funded, based in academic institutions) and applied research (industry funded, often based outside academic institutions), with an assumed linear relationship, was subsequently adopted by various editions the OECD *Frascati Manual*, as described and cited above. Bush describes his view of basic and applied research very clearly in the report:

> "Basic research is performed without thought of practical ends. It results in general knowledge and an understanding of nature and its laws. This general knowledge provides the means of answering a large number of important practical problems, though it may not give a complete specific answer to any one of them. The function of applied research is to provide such complete answers. The scientist doing basic research may not be at all interested in the practical applications of his work, yet the further progress of industrial development would eventually stagnate if basic scientific research were long neglected." [Bush, 1945]

Stokes points out that, whilst Bush's report was very influential, and did lead directly to the establishment of the National Science Foundation (NSF) in 1950, the form of the governance of the NSF was completely at odds with Bush's own vision of a self-governing agency (Stokes details the 5 year discussion on how the NSF should be legally constituted, these delays being due to disagreements on how to proceed). In contrast Bush's eloquent espousal of a linear model of innovation, from basic research, through applied research to industrial development (experimental development in OECD terms), has had a much more lasting effect, creating a narrowness of vision inappropriate for the future challenges of science

and technology policy, in Stokes' opinion. Stokes claims that "the irony of its [the report's] reception is deepened by the fact that the defeat of the plan made it *more* likely that its paradigm view of science and technology would triumph" [Stokes, 1997, p. 53]. So Bush's report, whilst not implemented in full, created the dominant paradigm for discussion of scientific and technological research funding to this day.

Stokes' idea is essentially to reunite research across the basic/applied schism. His model is that the two most common concepts used to define basic research should be treated as two separate axes defining four rather than two potential terms, allowing greater nuance and more precise usage, and merging basic and applied research. The two axes are the utility of research (basic = aimed at no use, applied = aimed at use) and the understanding of the domain that the research seeks to evolve (basic = fundamental, applied = not fundamental); these are used as two axes so that there are two binary responses on each axis.

Table 2.1: Stokes' Diagram of Pasteur's Quadrant

	Aimed at use? No	Aimed at use? Yes
Fundamental? Yes	Bohr's Quadrant (basic)	Pasteur's Quadrant (use-inspired basic)
Fundamental? No		Edison's Quadrant (applied)

Table 2.1 has been adapted from Stokes [Stokes, 1997, p. 73]. The key point to highlight is that there has been a strong tradition of mixing basic and applied research since the nineteenth century, with Pasteur as a key exemplar.

For those who are not familiar with the three scientists used to identify these quadrants a brief summary of their significance follows. Bohr (1885-1962) was a Danish physicist who made fundamental contributions to the understanding of atomic structure and quantum mechanics for which he received a Nobel Prize in 1922. Pasteur (1822-1895) was a French chemist best known for his remarkable breakthroughs in microbiology, and is regarded as one of the founders of bacteriology; he also made discoveries in the field of chemistry, most notably concerning the asymmetry of crystals. Edison (1847-1931) was an American inventor who developed many influential devices including the phonograph and a long lasting light bulb, and also established the first industrial research laboratory in Menlo Park, New Jersey.

The empty quadrant, although less significant, is still a valid one, populated by work that creates tools that help future research (such as developing low-level

taxonomies). Thus the activity here is neither fundamental research, nor aimed at external use by society (more at internal use by the research community itself).

So, in contrast to Bush, Stokes' view is that this artificial separation of basic and applied research is invalid. He describes his own view of a more complex overlap between basic and applied priorities that creates four quadrants, one of which is labelled "use-inspired basic research," or "Pasteur's Quadrant." Stokes also believes that continuing to hold onto the old paradigm is damaging in a number of ways. Stokes states clearly:

> "More is involved in these revised images of the links between basic science and technological innovation than their greater faithfulness to the annals of research. These revisions in the postwar paradigm are also of broad importance for science and technology policy. Indeed, the following five observations may carry across the threshold between analysis and policy:
>
> —The paradigm view of science and technology that emerged from Word War II gave a notably incomplete account of the actual relationship between basic research and technological innovation.
>
> —The incompleteness of the postwar paradigm is impairing the dialogue between the scientific and the policy communities and impeding the search for a fresh compact between science and government.
>
> —A more realistic view of the relationship of science and technology must allow for the critically important role of use-inspired basic research in linking the semiautonomous trajectories of scientific understanding and technological know-how.
>
> —A clearer understanding by the scientific and policy communities of the role of use-inspired research can help renew the compact between science and government, a compact that must also provide support for pure basic research.
>
> —Agendas of use-inspired basic research can be built only by bringing together informed judgments of research promise and societal need."
> [Stokes, 1997, p. 89]

The rest of Stokes' book addresses these issues. Clearly Stokes' observations represent one view of how a new model should be created that can capture the more complex, non-linear, processes that actually make up research and innovation.

2.3.2 OECD: Frascati Manual

The definitions of research and experimental development encapsulated in the *Frascati Manual* [OECD, 2002] have dominated formal documents addressing scientific research in most countries in the world from the first edition of the manual over forty years ago [OECD, 1963], and through a series of subsequent editions up to and including the sixth edition. Whilst the scope of the Frascati Manual is the measurement of the financial resources used for research and experimental development, its impact has been on the use of terminology in policy documents, terms of reference of funding bodies, and on the terminology used in the discussion of research and experimental development in general. The basic definition of research and development in the current edition of the manual is:

> "Research and experimental development (R&D) comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications."
> [OECD, 2002, Par. 63]

The manual goes on to define three tiers of R&D activity, each with differing time horizons to potential exploitation: basic research, applied research and experimental development. Furthermore basic research is subcategorised into pure basic research and oriented basic research.

> "Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts, without any particular application or use in view."
> [OECD, 2002, Par. 240]

> "Oriented basic research may be distinguished from pure basic research as follows: – Pure basic research is carried out for the advancement of knowledge, without seeking long-term economic or social benefits or making any effort to apply the results to practical problems or to transfer the results to sectors responsible for their application. – Oriented basic research is carried out with the expectation that it will produce a broad base of knowledge likely to form the basis of the solution to recognised or expected, current or future problems or possibilities."
> [OECD, 2002, Par. 243]

> "Applied research is also original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards

a specific practical aim or objective."
[OECD, 2002, Par. 245]

> "Experimental development is systematic work, drawing on knowledge gained from research and practical experience, that is directed to producing new materials, products and devices; to installing new processes, systems and services; or to improving substantially those already produced or installed."
> [OECD, 2002, Par. 249]

Whilst these definitions have been fairly stable over the various editions of the manual, more recent versions have added text acknowledging the lack of clear boundaries between the seemingly separate types of research activity defined:

> "There are many conceptual and operational problems associated with these categories. They seem to imply a sequence and a separation which rarely exist in reality. The three types of R&D may sometimes be carried out in the same centre by essentially the same staff. Moreover, there may be movement in both directions. When an R&D project is at the applied research/experimental development stage, for example, some funds may have to be spent on additional experimental or theoretical work in order to acquire more knowledge of the underlying foundations of relevant phenomena before further progress can be made. Moreover, some research projects may genuinely straddle categories. For instance, study of the variables affecting the educational attainment of children drawn from different social and ethnic groups may involve both basic and applied research."
> [OECD, 2002, Par. 251]

Similarly, the manual originally focused on engineering and the natural sciences, but more recent editions of the manual have addressed software (a new discipline that has emerged as a major player in technology since the 1980s) and social sciences (an older discipline that is now recognised as essential for mapping the relationships between science and society, and of studying society itself) as well. Other areas, in particular in the humanities, are still not represented in the Frascati definitions. Essentially, as governments have pushed to fund these types of research, they have been retrofitted for inclusion in the definitions.

> "In recent years, the desire for better information on R&D in service activities has been expressed. The basic definitions in this Manual were originally developed for manufacturing industry and research in the natural sciences and engineering. Specific problems therefore arise

> for applying them to service activities, which often involve software applications and research in the social sciences."
> [OECD, 2002, Par. 25]

Whether one accepts this terminology or not, it has had a strong impact on how any debate about R&D has been framed in the past forty years. In particular, these are the definitions used when compiling statistics about research and experimental development spending in OECD countries, so any use of these statistics in support of an argument often also involves an implicit alignment with the terminology and definitions. Indeed the authors of the manual are consciously aware of its influence in this regard:

> "Furthermore, by providing internationally accepted definitions of R&D and classifications of its component activities, the Manual contributes to intergovernmental discussions on 'best practices' for science and technology policies."
> [OECD, 2002, p. 3].

In summary, this subsection has explored the definitions of research, and probed the binary paradigm of basic and applied research. It has traced, through Stokes' analysis, this paradigm back to Vannevar Bush's influential report in 1945. It has shown that this terminology, and this paradigm, is alive and well in the OECD *Frascati Manual*, the definitions that directly define how research and development statistics are recorded throughout the world today. Chapter 4 will probe more deeply into competing theories of research and development within a wider innovation framework further. The purpose of this introduction has been to explain the terminology of the debate clearly enough to articulate relevant research questions.

2.4 Irish Context–Thesis Timeline

In Chapter 3 there is a detailed discussion of the Irish innovation system, the agencies involved, and the context for the development of Irish research funding policy. In particular Section 3.4 discusses the historical development of Ireland's STI policy, and Section 3.5 discusses the economic development strategy, and Foreign Direct Investment (FDI) as a pillar of that strategy. However, since the research questions below have an explicit time period, it is necessary to be clear from the outset why the time period was chosen. This section thus presents a summary of this context and the reader is referred to the next chapter for more detail on the agencies.

Ireland's economy has been described as "innovation by invitation" [O'Malley et al., 2006, p. 51], a reference to the importance of Foreign Direct Investment (FDI) to the economy. From the foundation of the state Ireland lacked a vibrant industrial base, and the economy was driven by agriculture. In the 1950s and 1960s Ireland opened up its economy and started to encourage FDI, particularly of US-based companies, mainly driven by a cheap labour force and access to the Irish and UK markets. The 1960s and 1970s saw the benefits of this approach. Significantly Ireland was a founder member of the OECD in 1960, and Ireland joined the European Union, then known as the European Economic Community, in 1973 (having been rejected in 1961). Since then Ireland has been a poster child of the benefits of EU membership, and has transformed its economy from an agricultural one feeding the UK market, to one of the most open economies in the world, with a vibrant ICT and bio-technology sector, as well as continuing to grow its traditional agricultural strength internationally. It has become the gateway to the EU market for many US multi-nationals and has thus developed its FDI strategy to be the envy of many other countries in Europe.

Thus in the early 1990s Ireland was ready for a more mature attitude towards investment in R&D in its own education system. Two forces came together to push for this investment. The Irish agency responsible for FDI, the Industrial Development Authority (IDA), recognised the fact that as Ireland's costs increased, and as new members joined the EU with lower cost bases, and as globalisation allowed more dramatic outsourcing to India, China and other developing countries with very much lower cost bases, Ireland could no longer pursue an FDI strategy based on manufacturing alone. It believed the only solution was to move up the value chain towards R&D, developing a knowledge-based economy. This terminology was becoming prevalent with the OECD and the EU policy making communities, and it reached its logical conclusion in 2000 as the Lisbon Agenda made the knowledge economy the primary economic target for the EU, and specified a target of 3% GDP investment in R&D by 2010 (this target includes public and private sector investment). This approach, being promoted by the IDA and others, required the development of research in HEIs to create links with which to encourage the new form of FDI—locating multi-national R& in Ireland. In combination the Irish academic and educational system, catalysed by success in EU-funded research programmes in the late 1980s and early 1990s (e.g. ESPRIT, ACTS), lobbied for a more developed national research funding system. The Culliton Report [Culliton, 1992] and the subsequent STIAC Report [STIAC, 1995] argued for increased investment in R&D, and for a recognition of the link between a healthy public sector research system and economic growth.

Therefore this thesis has a strong argument for beginning its analysis with the second of these seminal reports, [STIAC, 1995], that established a momentum

that led to the creation of two large new funding schemes for research in HEIs in Ireland, and a number of smaller ones: HEA PRTLI and Science Foundation Ireland. Chapter 6 analyses the period 1995–2000, the policy formation texts, and Chapter 7 analyses the period 2001–2008, the policy implementation texts (when these funding programmes were operational).

2.5 Research Questions

The focus of this thesis is to address these two related questions:

> *Was Irish funding policy in the 1990s based on an idealistic notion of basic research?*

and

> *Will future funding policy be based on a more pragmatic understanding of the value of applied research?*

Here the issue of the definitions of basic and applied research, and their origins in Vannevar Bush's outline for postwar government support for research, and its implied linear model from basic through applied to pre-product development and commercialisation, are key (c.f. the discussion in Section 2.3.1). The allusion is to Stokes' revised ideas of the overlap between basic and applied research, and the futility of continuing to separate them completely in policy, as has been the tradition since Bush.

This question could be reframed as an analysis of the process of contextualisation of scientific research, not yet complete. So, one could rephrase the same question:

> *Is there evidence in the development of Irish research funding policy for a contextualisation of science, engineering and technology?*

This has been selected as the preferred form of the *core question*, though it requires some explanation of what is meant by contextualisation. Here the question is whether the pressure to contextualise, i.e. make research relevant to various stakeholders, including society itself, is actually a pressure to collapse the boundaries between basic and applied research, as articulated in the previous question.

A simplified form of the argument is that by insisting on the primacy of "basic research" what is often being defended is the autonomy of scientists: their ability to research the areas that interest them, driven by curiosity. Thus, an instance on the primacy of "basic research" can indicate a tendency to resist any external context for science, treating it as a law unto itself with internal validity.

As will be argued in later chapters, particularly Chapter 4, differing attitudes to contextualisation can be traced through models that are used for research and innovation—some models treating SET within a wider societal context, and others allowing it to exist within purely its own terms.

This seems to form a defined scope for the analysis, where the potential activity is clearly bounded and reasonable. One would have to be open to the possibility that the hypothesis would be disproved, and that there is no such evidence. My belief is that there has been a shift within the period identified, in particular within Science Foundation Ireland (from their foundation) who control the majority of basic research funding in Information and Communications technologies (ICT) and Biotechnology, towards an acknowledgement of the importance of commercialisation and of contextualising research outputs. My aim in this thesis is to explore this possibility in a structured way.

So, the essential focus is on the contextualisation of science, and thus on research funding policy, on the research policies of the groups, centres and institutions targeting that funding, and ultimately on the linkage of the research activity into an innovation lifecycle. This raises a number of interesting *ancillary questions*:

- *Has Irish research funding in the 1990s produced any measurable economic benefit?*
- *Do Irish policy makers and researchers agree on a definition of basic and applied research?*
- *Does the way the policies prioritise issues translate into proposal and project evaluation?*

Inclusion of the last of these three may imply that the rhetoric of policies is often a long way from the reality on the ground. In this case the process of evaluating proposals for funding, and of evaluating whether progress has been made in funded research projects is controlled by the peer group of academics who may well still hold traditional views of the role of science engineering and technology and thus value traditional priorities over emerging priorities (despite the policies of the research programmes themselves reflecting the latter). I intend to address aspects of all these questions, with the emphasis on the core research question, reiterated in the next paragraph for clarity.

Thus this thesis aims to directly address the following core research question:

> *Is there evidence in the development of Irish research funding policy for a contextualisation of science, engineering and technology?*

and to address aspects of the ancillary questions detailed above.

2.6 Summary

This chapter has outlined the terminology used in the title of the thesis and has explored the origins of this terminology. Then it has framed the core research question in two forms, and has outlined some subsidiary questions.

The thesis continues with two more contextual chapters

- a detailed description of the Irish Innovation System with a focus on the agencies involved in publicly funded research for SET in Chapter 3;
- a detailed analysis of the theoretical framework for understanding SET policy in Chapter 4;

before addressing the core work of the thesis

- the methodology and method in Chapter 5;
- the analysis of key texts in Chapter 6 and Chapter 7;
- the discussion of the issues raised in Chapter 8.

Chapter 3

Contextual Framework: The Irish Innovation System

Before embarking on a detailed analysis of the research funding policy documents it is important to set the context for this work. This chapter aims to introduce the entities, agencies, bodies and institutions involved in science and technology research in Ireland, the Irish Innovation System. It acts as a contextual framework at a deeper level than merely examining the terminology (as was done in the previous chapter) by describing in detail the multiple entities that make up the national innovation system in Ireland. This chapter is balanced by the following chapter (Chapter 4 *Theoretical Framework*) that examines theoretical models for understanding how research and development link to science, technology and innovation.

There have been few academic analyses of the Irish research and innovation system relative to bigger economies such as the United Kingdom or the United States of America. The most prominent authority is Joe Cogan, a Professor at University College Dublin's Department of Business Administration and director of the Science Policy Research Centre based there [Cogan and McDevitt, 2000, 2003; Cogan, 2003]. A more recent source of academic analysis of Ireland's research and innovation system is the Centre for Innovation and Structural Change (CISC) in NUI Galway [Geoghegan and Pontikakis, 2008]. Much of this work has been funded by EU projects aimed at contributing to knowledge of the research and innovation systems in Europe such as CONVERGE and KNOGG. The Irish agency Forfás, who have responsibility for contributing background information to inform policy for research and innovation, have carried out their own surveys, and have commissioned external consultant reports, as have some of the other agencies such as the Higher Education Authority (HEA). A good summary of the processes that led to the development of new policies relating to funding research

in HEIs in Ireland can be found in Hayden [Hayden, 2002].

Industrial research in companies and in dedicated industrial research entities is considered to be outside the remit of this thesis. Arguably, Ireland has few such industrial research entities, with much Foreign Direct Investment (FDI) being centred on manufacturing (e.g. Intel's silicon chip facilities—the largest FDI employer in Ireland) and tele-services (e.g. Microsoft's European telephone support conducted via call centres in Ireland) in the 1990s. Although statistically more is spent on research in business than in Higher Education (see 3.1), what is certainly missing in Ireland are entities that span the gap between academia and industry, such as the Fraunhofer Institutes in Germany:

> "The country missed out on institutions such as technological universities and industry laboratories that are a feature of the industrial landscape in most European countries. In addition, Ireland's chosen path to industrialisation, i.e. following the FDI route, masked until very recently this deficiency in the research infrastructure, and in the intermediaries that help bridge the gap between enterprise and the research base."
> [Cogan, 2003, p. 37]

The focus of this thesis is the research and development funded by government and carried out in the Higher Education Institutions (HEIs), and how this relates to government policy and to the economic environment. Issues relating to the links between this higher education research and industry are of course important.

3.1 Agencies in the Irish Innovation System

3.1.1 Higher Education Institutions

In Ireland at the start of the twenty-first century the higher education system is a binary system comprising universities and Institutes of Technology (IoTs). There is also a growing state-owned further education sector, and a growing number of private colleges. However, as far as funded science and technology research is concerned, the universities and the institutes of technology are the places where publicly funded research activity currently happens, and primarily at the universities, sometimes with industrial partnerships.

The universities are mainly made up of institutions which predate the establishment of the state: The University of Dublin (Trinity College Dublin), and the National University of Ireland (NUI). The history of the NUI shows that it evolved from the Queen's Colleges of Cork, Galway and Belfast established by law in 1845, and the rival Catholic University of Ireland, with John Henry Newman

as its first Rector, who wrote one of the core texts in the western tradition justifying the need for a liberal education [Newman, 1854]. These various institutions eventually merged, (with the exception of Queens College, Belfast, that remained in the United Kingdom), and were restructured as recently as 1997 into constituent universities (NUI Cork, NUI Dublin, NUI Galway, and NUI Maynooth) and recognised colleges (e.g. Royal College of Surgeons). Confusingly, two of the constituent universities still use the old form of their name: University College Cork (UCC) and University College Dublin (UCD). To this set of institutions have been added two modern universities which were originally called National Institutes of Higher Education (NIHE) but have since been upgraded to universities: University of Limerick (UL) and Dublin City University (DCU)—arguably these have a more applied focus in their curricula having come from a different tradition. The majority of the universities are currently represented at national policy level by the Irish Universities Association (IUA), previously called CHIU (Conference of Heads of Irish Universities), who have contributed a number of policy documents to recent national educational debates. The most recent legislation confirming this relationship was established in the Universities Act 1997 [Irish Government, 1997] that formally defined a process for other institutions wishing to become universities, effectively setting a high bar for potential new entrants.

The institutes of technology include Dublin Institute of Technology (originally a series of separate technical colleges in Dublin which were amalgamated into a single institution), and a range of institutions which were originally called Regional Technical Colleges (RTCs). The RTCs were renamed Institutes of Technology (IoTs) in 1996. The RTCs were set up in the 1970s as regional training centres, with little research culture. Since 1992 research has been an official part of their remit, but they do not receive any baseline funding for this activity. In practice the RTCs had engaged in some regional development and consultancy activities prior to this official change; it was potentially to recognise and enable this that the new act included the remit to do research. "The RTCs and DIT have an important contribution to make as sources of technical support for local industry especially in meeting the needs of SMEs for applied and developmental research" [CIRCA, 1996, Rec 7.4 Para 3c]. The current list of IoTs is: Cork, Waterford, Galway Mayo, Athlone, Tallaght, Letterkenny, Dundalk, Dun Laoghaire, Carlow, Sligo, Tralee, Limerick and Blanchardstown. The institutes of technology are currently represented at national policy level by the Council of Directors (this does not include DIT). The last official acts of legislation defining the roles of these institutions were the Institute of Technology Act 2006 [Irish Government, 2006] RTC Act 1992 [Irish Government, 1992b] (amended in 1994 and 1999) and the DIT Act 1992 [Irish Government, 1992a] (amended in 1994). The RTC Act

(1992) predates the change of name from RTCs to IoTs in 1998, that did not require legislation.

Additionally there are two public bodies which directly engage in research: Teagasc (Food Science) and the Dublin Institute for Advanced Studies (Physics, Mathematics and Irish).

3.1.2 Science and Technology Research Funding Agencies in Ireland

In Ireland, public science, engineering and technology research is funded, in the main, by the following government departments and state bodies.

Government departments—full list

This is a full list of Irish Government departments, with some notes on new names introduced over the period 1996-2008. This list is ordered to emphasise those departments with most input into Science, Technology & Innovation (STI) policy formation. For a list of current and past ministers in key departments see Appendix C.

- Department of the Taoiseach—this is the department for the Irish Prime Minister;

- Department of Education and Science (DES)—directly administered the Institute of Technology sector 1992–2007, and all primary and secondary level education (i.e. primary and secondary education is controlled centrally in Ireland rather than being devolved as in many other countries), in 2007 delegated control of Institute of Technology sector to the HEA, who had responsibility for the universities alone until then—was renamed Education and Skills (DES) as part of a restructuring of departments in March 2010 (after the policy period that this thesis analyses);

- Department of Enterprise, Trade and Employment (DETE)—responsible for funding industry research and academic research with industry links—was renamed Enterprise Trade and Innovation (DETI) as part of a restructuring of departments in March 2010 (after the policy period that this thesis analyses);

- Department of Health and Children (DOHC);

- Department of Agriculture and Food—Fisheries was added in 2007: Agriculture, Fisheries and Food;

- Department of Communications, Marine and Natural Resources (DCMNR)—the Marine was removed in 2007, being replaced by Energy: i.e. Communications, Energy and Natural Resources (DCENR);
- Department of Arts, Sport and Tourism;
- Department of Community, Rural and Gaeltacht Affairs—the Gaeltacht is the collective word for Irish speaking areas in Ireland;
- Department of Defence;
- Department of Environment, Heritage and Local Government;
- Department of Finance;
- Department of Foreign Affairs (DFA);
- Department of Justice, Equality and Law Reform;
- Department of Social and Family Affairs;
- Department of Transport and the Marine.

All departments are listed as it is possible for any department to setup its own research funding scheme and advertise directly to the community for uptake. However the majority of research funding in Ireland is channeled through state funding agencies rather than provided directly by departments.

Of these departments, DES (Education) and DETE (Enterprise) have most to do with the administration of research funding in higher education. The prime minister's (An Taoiseach's) department plays a key role in co-ordinating science policy. As in most countries, the Department of Finance is pivotal as a gatekeeper for all exchequer funding.

State research funding bodies—selected

This is a list of selected state bodies, in general linked to one of the government departments listed above, who have responsibility for research funding. This list includes agencies (that are nor departments) responsible for allocating research funding. IN addition some funding comes directly from some departments rather than via a subordinate agency.

- Higher Education Authority (HEA)—administers the university sector and took over administration of the Institute of Technology sector in 2007 (the IoTs were previously eligible to apply for HEA research funding, so this change did not of itself have a major impact on the research funding for IoTs);

- Science Foundation Ireland (SFI)—was established in 2000, as a sub-board of Forfás, to administer Ireland's Technology Foresight Fund (with its original focus on biotechnology and information and communications), in July 2003; SFI was established on a statutory basis under the Industrial Development (Science Foundation Ireland) Act, 2003;

- Enterprise Ireland (EI)—formerly known as EOLAS and then Forbairt, this agency focuses on the development of indigenous industries targeting internationally traded services, it administers research grants for academic research linked to potential exploitation;

- Health Research Board (HRB);

- Industrial Development Authority (IDA)—responsible for foreign direct investment (FDI), but now with a brief to prioritise FDI investment in research activities; it cannot award research funding directly to Irish academia, but it can award grants as FDI with an industrial research element that may include links to Irish academics.

- Environmental Protection Agency (EPA);

- The Marine Institute (MI);

- The National Council for Forest Research and Development (COFORD);

- Irish Research Councils:

  - Irish Research Council for the Humanities and Social Science (IRCHSS), some social science research looks at STI/SET policy itself so could be considered relevant to SET indirectly (founded in 2000).
  - Irish Research Council for Science, Engineering and Technology (IRCSET) (founded in 2001);

As discussed above, some government departments operate some research funding schemes directly, rather than via one of these state research funding bodies, but most Irish research funding is channeled via these agencies.

Research funding is also provided by international agencies, most of it from the European Commission's framework programmes and the UK-based Wellcome Trust. Until the mid 1990s, the availability of national science and technology research funding (other than medical funding) was very limited and these international sources were the main mechanism for funding research in SET in Irish academia.

3.1.3 Groups Contributing to Science and Technology Policy in Ireland

To some extent there is an overlap between this category and the previous category (research funding agencies), as the research institutions and the funding agencies themselves both contribute to policy debates. In particular, the conglomerate agencies representing the university sector (i.e. the Irish Universities Association—IUA—formerly called CHIU) and the institutes of technology (i.e. Council of Directors—CoD), and the funding agencies with the largest profile (HEA, SFI, EI, IRCSET) make regular contributions to the emerging national discussion of research policy, and of science and technology funding in general.

There are a number of other agencies, that do not directly conduct science and technology research, or fund it, but do have a significant impact on research funding policy (acting as catalysts driving the processes for the creation of new funding agencies). These agencies are usefully summarised by the pamphlet [Forfás, 2001] listing the agencies Supporting the "Development of Enterprise, Trade, Science, Technology and Innovation" in Ireland.

The main national development and policy agencies are:

- Forfás (under DETE)—policy advisory and co-ordination board for enterprise, trade, and science and technology in Ireland;
- Advisory Council for Science Technology and Innovation (ACSTI), established in April 2005 replacing the Irish Council for Science, Technology and Innovation (ICSTI) that was established in 1997—advises the Minister for Science and Technology and the Government on the strategic direction of STI policy and on specific issues important to the development of science and technology in Ireland;
- Expert Group on Future Skills Needs (EGFSN) established in 1997 (links DETE and DES)—aims to identify, in a systematic way, the skill needs of different sectors and to advise on the actions needed to address these as part of a partnership process on these issues between the Government and business, education, training and employee representatives;
- Industrial Development Agency (IDA under DETE)—promotes foreign direct investment in Ireland;
- Enterprise Ireland (EI under DETE)—listed above as a funding agency;
- Science Foundation Ireland (SFI under DETE)—listed above as a funding agency.

Two specialist regional development agencies also exist:

- Shannon Development (under DETE)—responsible for development and innovation in the Shannon region in counties Limerick and Clare;
- Údarás na Gaeltachta (under DETE)—responsible for development and innovation in officially designated Irish-speaking areas in Ireland known collectively as the Gaeltacht; these areas are widely dispersed but generally on the western seaboard.

Agencies listed in the Forfás summary but omitted here, in the context of ST research and STI, as not being highly relevant are: National Competitiveness Council, National Accreditation Board, and FÁS (Irish Training and Employment Authority).

Two agencies should be mentioned that are not listed in the Forfás summary. One is an advisory group outside the rest of the enterprise, trade and industry framework, the other an office in a government department:

- Information Society Commission (ISC) — independent advisory body to Government, reporting directly to the Taoiseach (Irish Prime Minister)
- The Office of Science and Technology (OST) — situated within the Enterprise, Science and Technology Division of the DETE is responsible for the development, promotion and co-ordination of Ireland's STI policy.

> "Prior to the formation of the new government in June 2002, the OST reported to a Minister of State for Science, Technology and Commerce who had responsibility for the overall science and technology budget, and for the Technology Development Programme under the Ministers for Enterprise, Trade and Employment and Education and Science. In the new government arrangements the Minister for Enterprise, Trade and Employment has assumed direct responsibilities for these areas."
> [Cogan, 2003, p. 11]

In general, most of the funding for Ireland's STI policies comes from the National Development Plan:

- National Development Plan (NDP 1989)—1989-1993.
- National Development Plan (NDP 1994)—1994-1999.
- National Development Plan (NDP 2000)—2000-2006 investment plan for Ireland involving an investment of €57 billion.
- National Development Plan (NDP 2007)—2007-2013 investment plan for Ireland involving an investment of €184 billion.

Originally these investment plans were driven by the EU procedures for managing EU funds to aid national development, including the structural funds prioritising regions of most need (all of Ireland was initially Objective 1, in most need). As the Irish economy has developed, the NDP has become more of a mixture of national and EU funds with matched private funds in some cases.

3.2 Note on the Binary Higher Education System

One key change in the higher education system in Ireland in 2007 was that the institutes of technology, previously administered directly by the DES (Department of Education and Science), were re-designated to be under the remit of the HEA (Higher Education Authority). This was in response to an OECD review of higher education that recommended a new authority be established to oversee both elements of the higher education system [OECD, 2004]. It should be noted that the Minister for Education at the time was very clear that Ireland would continue to have a binary higher education system with institutions operating according to different missions, despite a unified reporting structure to the HEA.

> "There is one further extremely important dimension to the expanded role of the HEA that I want to refer to. An important determinant of the success of higher education in supporting national priorities will be the extent to which we can retain a higher education system composed of institutions with diverse missions. The new legislation that we have enacted creates a unified higher education system under one funding and regulatory agency. A unified system, however, is quite different from a homogenous one. In their review of Ireland's higher education system, in which they recommended the unified strategic framework that is now in place, the OECD paid considerable attention to the great strength of diversified institutional missions in our system.
>
> It is firm Government policy that we should retain in our higher education system a range of institutions with a diversity of mission, broadly in two separate but interlinked sub-sectors. This is not about curtailing institutions or placing limits on their development. It is about ensuring that, as institutions are supported in developing according to their strengths, they do so in the context of a clear system-wide vision of how best to meet the full range of needs of our society - for skills provision, industry collaboration and the generation and use of new knowledge. The enhanced autonomy and managerial freedoms being provided to the institutes of technology under the new legislation is a very positive and necessary step in their evolution.

> It will ensure that individual institutes have the necessary scope to build on their strengths in contributing to that system wide approach to meeting national needs. I expect the HEA, through its funding mechanisms, procedures for programme approval, strategic review and overall in exercising its planning and development role to ensure that we retain the rich mix of provision which at present characterises our system."
> Address by Minister Hanafin T.D. to the Heads of higher education institutions following the inaugural meeting of the new Higher Education Authority
> [Hanafin, 2007]

This point explicitly references the concerns raised in the OECD report about "mission drift" of some institutions in the Institute of Technology sector: "That steps be taken to coordinate better the development of the tertiary education system by bringing the universities and the institutes under a new common Authority, the Tertiary Education Authority, but that machinery be established within the Authority to prevent mission drift" [OECD, 2004, Recommendation 2]. So the reconstituted HEA, as of February 2007, now is effectively the "Tertiary Education Authority" as recommended by the OECD, though it has retained its original name.

3.3 Measuring the Irish Innovation System: OECD

This thesis analyses the policy documents that have formed Ireland's Science, Engineering and Technology (SET) policy from 1995–2008. A large part of the rationale for the selection of this time period is that this period saw a large change in the level of public funding for research. This thesis attempts to probe the policy texts to see how this increase was justified, particularly in terms of economic justifications.

Chapter 2 described the OECD's definitions of research and how these were used to gather national statistics. These statistics are now published in a series called the *Main Science Technology Indicators* [OECD, 2007]. These indicators include the Gross Domestic Expenditure on Research and Development (GERD), the Business Enterprise Expenditure on Research and Development (BERD) and the Higher Education Expenditure on Research and Development (HERD).

The gross figures are normalised to US dollars using Purchasing Power Parities (PPP). The trend in the past ten years has been for Irish gross spending to have increased more than its EU neighbours, as can be seen in Figure 3.1 (note the scale for the EU15 is on the left, and that for Ireland on the right—it would

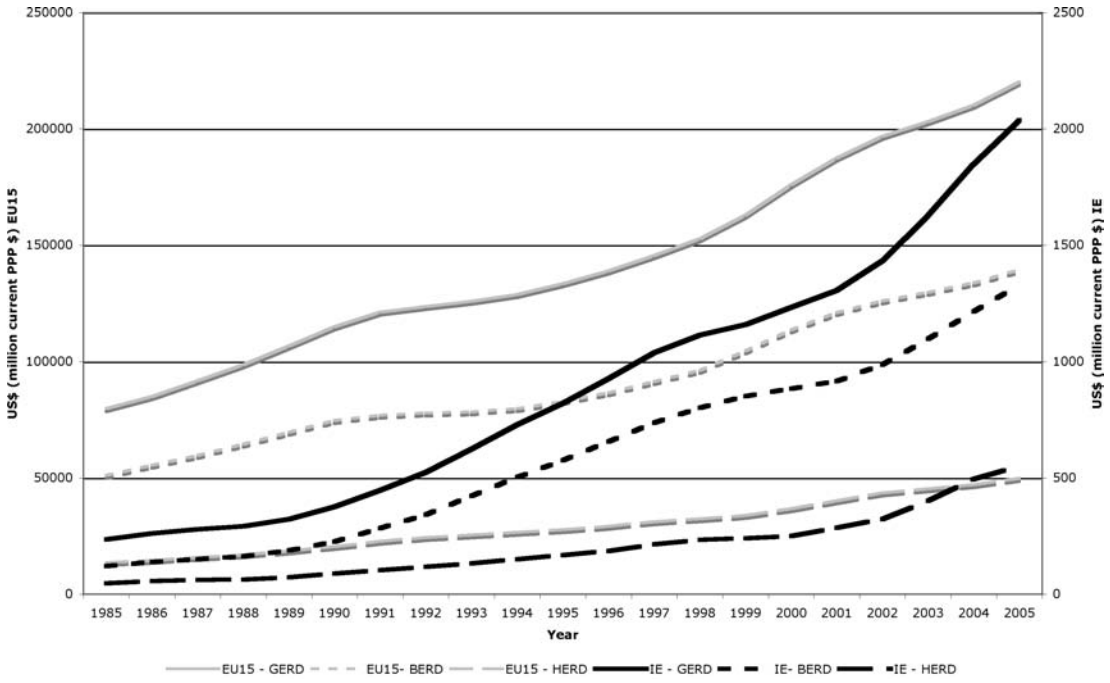

Figure 3.1: Irish (IE) and EU-15 GERD, BERD and HERD (as Gross Figures)

not make sense for Ireland to be spending as much as all of the EU15 countries combined).

The gross figure uses two different scales on the Y axis in Figure 3.1—one for Irish spending and one for EU-15 spending. In both figures the grey lines represent figures for Ireland and the black lines figures for the EU-15, in addition the solid line is GERD (gross BERD and HERD), the dotted line is BERD (business research spending), and the dashed line is HERD (higher education research spending).

The same indicators, but normalised as a percentage of the GDP (Gross Domestic Product) in Figure 3.2, show that Ireland's R&D expenditure has been keeping up with its own GDP (which has increased), but is not performing significantly better than its EU neighbours. The aim of spending 3% of GDP (GERD) on research and development by 2010, sometimes known as the 'Barcelona target', is part of the Lisbon Agenda [EU Commission, 2000].

These figures demonstrate that there has been a huge increase in the gross spending on research and development in Ireland, and that there has been a very significant increase in spending on research and development in the higher education sector. In particular, in the past three years for which records exist, 2003–2005, the rate of growth has been greater in Ireland than in the EU-15 (this is very obvious in the gross figures, but could also be argued for the figures as

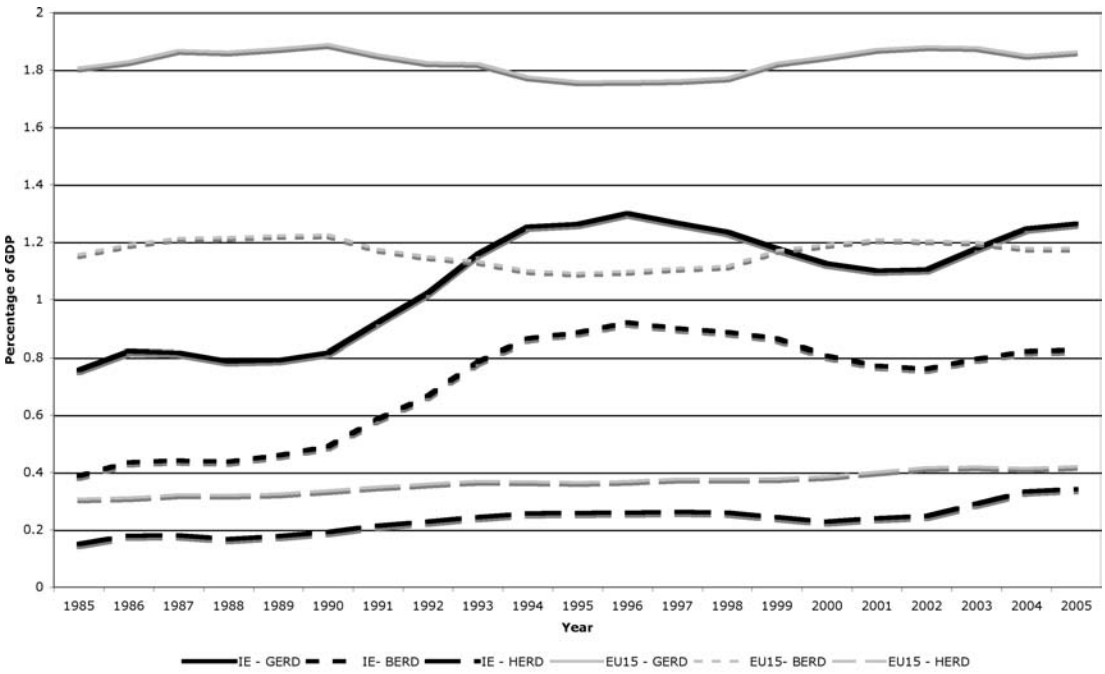

Figure 3.2: Irish (IE) and EU-15 GERD, BERD and HERD (as Percentage of GDP)

a percentage of GDP). This increase in spending forms a significant part of the background context for the development of SET policies. Typically, although not demonstrated in these figures, the majority of research and development funding is on SET. In Ireland this is underscored by the simple fact that the only two areas funded by Science Foundation Ireland are Information Communications Technologies (ICT), and the Biological Sciences. In addition, as in many countries, the funding given by the HEA to all disciplines tends towards higher awards for SET departments than Humanities or Social Sciences.

These figures are presented as a key part of the context for Irish policy, rather than as a part of the analysis itself. The stated target of the Lisbon Agenda, and of Ireland, is for the GERD to be 3% of the GDP by 2010. The current level in Ireland is around 1.2%, as can seen from Figure 3.2.

3.4 Historical Development of STI Policy

As will be explained in more detail in Chapters 6 and 7, through an analysis of the key documents, the current process of emphasising the importance of research and development can be traced back to the mid-1990s and a series of reports,

and probably more importantly actions following those reports implementing the majority of the recommendations.

The Lynch-Miller report on *Science and Irish Economic Development*, commissioned in 1963 and published in 1966 [Lynch and Miller, 1966], was perhaps the first significant step on the route towards investment in research and development. The report, along with OECD pressure could be considered to have led to the foundation of the National Science Council to advise on research, development and technology policy. Later in the 1960s the government introduced the first grants to support industrial research and development.

In the early 1970s the National Science Council produced a number of reports, including Cooper and Whelan [Cooper and Whelan, 1973], that highlighted poor Irish performance relative to other OECD countries in terms of expenditure on research and development in industry.

In the 1980s several influential reports were published:

1. The Telesis Report [Magaziner, 1982], a review of Irish industrial policy that recommended that policy should focus more on indigenous industry, and on addressing weaknesses in management, marketing and technology;

2. The National Economic and Social Council [NESC, 1982] report on industrial policy.

3. A whitepaper on *Industrial Policy* [DETE, 1984] which was published two years after these reports.

However, it was the 1990s that saw a real sea change in attitudes to SET in Irish industrial policy. A whole series of reports contributed to this change in attitude: the Culliton Report [Culliton, 1992], The STIAC Report [STIAC, 1995], and the CIRCA Report [CIRCA, 1996]. These contributed to the first government *White Paper on Science, Technology and Innovation* [OST, 1996]. In their end-of-year report the director of Forfás highlights the key elements of this publication, and its genesis in the earlier reports:

> "The first ever Government White Paper on science, technology and innovation was launched on behalf of the Government by the Minister for Commerce, Science and Technology in November 1996. It marks a new beginning in the national approach to science and technology. The White Paper evolved from the work of the Culliton Report, the Science, Technology and Innovation Advisory Council (STIAC) and of the Task Force on the implementation of the STIAC Report chaired by the Chief Executive of Forfás. The White Paper aims to locate science and technology firmly within the framework of wider industrial, economic and national development policies.

A number of decisions in the White Paper were identified for priority action. These include:

- the establishment of a new interdepartmental committee to ensure a coherent and comprehensive approach to national expenditures on science and technology;
- the establishment of a Science Council with representatives of industry, universities, research organisations and other interests, to provide strong and objective advice which would contribute to the national science and technology planning process;
- additional actions by Forbairt to increase the level of technology transfer in industry;
- an initiative on inter-firm collaboration which would encourage firms to co-operate in strategic activities, such as research and development, and help to overcome disadvantages of small scale;
- new structures to achieve more effective management of the important Programmes in Advanced Technology;
- a campaign to increase the level of awareness and greater appreciation of the importance of science, technology and innovation.

Forfás will have a substantial involvement in the implementation of the decisions set out in the White Paper. The new Science Council will be established by Forfás, in consultation with the Minister for Commerce, Science and Technology. Forfás will manage the awareness campaign on Science and Technology issues and will have an important role in monitoring the implementation of the decisions announced in the White Paper."
[Forfás, 1996]

In subsequent years many of the key bodies were established to help pursue the science, technology and innovation policy, here these are listed in chronological order, but note that some of the items represent a renaming or re-branding of a previous body:

- Forbairt (1994)—established to be Ireland's industrial development agency with responsibilities that included managing research funding aimed at linking academia and industry, in particular the PATs (Programmes for Advanced Technology) and the BRG (Basic Research Grant scheme). Prior to the large investment in research in the higher education institutions in the late 1990s these were the largest sources of research funding for academics

"Forbairt was established on 1 January 1994 as an Agency of Forfás under the provisions of the Industrial Development Act, 1993. Our aim is to support Irish firms in all sectors, together with overseas companies operating from Ireland in the food and natural resources sectors, across a range of commercial activities including management, product development, and finance. Central to this aim is the goal of bringing science and technology to the centre stage of Irish economic development." [Forbairt, 1998];

- Forfás (1994)—established to the national policy and advisory board for enterprise, trade, science, technology and innovation;
- EGFSN (1997) Expert Group on Future Skills Needs—analyses industry needs for training and feeds into policy—Forfás provides administrative and research support;
- ICSTI (1997) Irish Council for Science Technology and Innovation—effectively a modern version of the National Science Council that had lapsed after its activity in the 1970s—Forfás provides administrative and research support;
- EI (1998) Enterprise Ireland—replaced Forbairt—responsible for indigenous industry and for applied research linking academia and industry—it revised the PATs and produced a series of funding instruments collectively termed the Commercialisation Fund (CF) that now comprise the majority of applied research funding available in Ireland;
- Technology Foresight (1998)—is a set of activities carried out by ICSTI "An objective of Technology Foresight is to identify future-proof strategies which will ensure that the science and technology infrastructure of a nation has the capacity to promote and support innovative industry into the future. Accordingly, the Irish Council for Science Technology and Innovation (ICSTI) started Ireland's first Technology Foresight exercise in March 1998. The Council established eight Technology Foresight Panels to consider the future technology needs of key sectors." [ICSTI, 1999]—identified the two sectors of Biotechnology and Information Communications Technologies as strategically important and thus the SFI was established and charged with prioritising these two areas;
- SFI (2000) Science Foundation Ireland—established on the model of the NSF (National Science Foundation) in the United States of America to manage research funding awarded to individual principal investigators primarily for research programmes in Biotechnology and Information Communications Technologies (as identified by the Technology Foresight exercise to be national priorities);

- OSTI (2004) the Office for Science Technology and Innovation—responsible for the development, promotion and co-ordination of Ireland's STI policy; and Ireland's policy in European Union and international research activities;
- IRCHSS (2000) Irish Research Council for the Humanities and Social Science;
- IRCSET (2001) Irish Research Council for Science Engineering and Technology;
- ACSTI (2005) Advisory Council for Science, Technology and Innovation—in April 2005 the ICSTI was re-branded as ACSTI, more recently the abbreviation preferred is ASC, the Advisory Science Council, though the logo still uses the full name of ACSTI.

The HEA (Higher Education Authority) already existed as the body that managed relations with the Irish universities. A new research funding programme was established, the PRTLI (Programme for Research in Third Level Institutions), administered by the HEA, but open to the Institute of Technology (IoT) sector as well as the universities. This funding was organised into a series of cycles in the period 1999 to 2007 (grand total €865.7 Million):

- Cycle 1 announced in 1999, funding period 2000-2003, total funding €206.1M;
- Cycle 2 announced in 2000, funding period 2001-2004, total funding €78.5M;
- Cycle 3 announced in 2001, funding period 2002-2006, total funding €320.4M;
- Cycle 4 announced in 2007, funding period 2007-2011, total funding €230M.

These funding cycles were administered as institutional submissions, i.e. a single integrated submission from each university, with internal research strategy deciding which sub-proposals would be incorporated in each institution's integrated capital and recurrent proposal. Thus a significant side effect of this process has been the maturity of the institutional research strategies that now exist compared with the mid-1990s. Indeed a formal submission of the institutional research strategy was required as part of the submission process, and played an important part in the evaluation process. Cycle 5 (total funding €300M was announced in January 2009.

At the heart of the integrated STI policy for Ireland are the Department of Education (that oversees HEA), and the Department of Enterprise, Trade and Employment (that oversees IDA, EI and the SFI). These departments collaborate on an integrated policy for science and technology, with the support of the Department of the Taoiseach (prime minister).

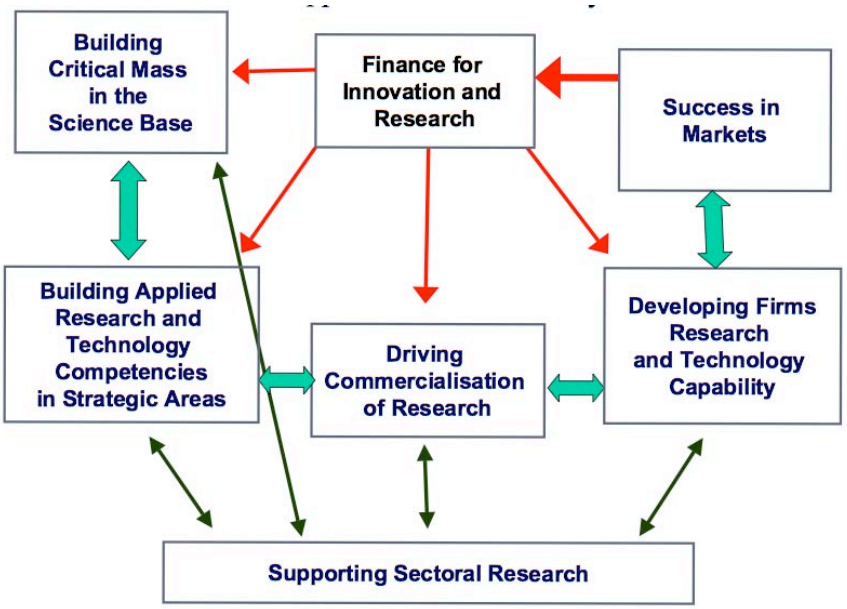

Figure 3.3: Irish National System of Innovation

The key document combining policy for R&D and Innovation is the SSTI (Strategy for Science, Technology and Innovation 2006–2013) [ASC, 2006], which defines the formal role the OSTI, the cross-departmental Office of Science and Technology (that was established as a result of some earlier recommendations of the the ICSTI and Foresight exercises) and provides operational oversight and formally reports to the Department of the Taoiseach, but oversees the inter-departmental activity.

The SSTI provides figures for two elements of the Irish system of research and innovation as appendices. The first is what it labels "The National System of Innovation" [ASC, 2006, p. 92] reproduced here as Figure 3.3. The second is a diagram of the agencies involved in implementing the strategy [ASC, 2006, p. 93] reproduced here as Figure 3.4.

3.5 Discussion

Whilst the research funding in Ireland has increased dramatically over the past decade (1997-2007), the overall culture in Ireland has been one of economic development by invitation, relying on high levels of foreign direct investment (FDI) to drive the economy. Originally this grant-aided support, channeled through the IDA, focused on manufacturing (e.g. electronics and pharmaceutical companies) and services (e.g. call centres); more recently this support has shifted to-

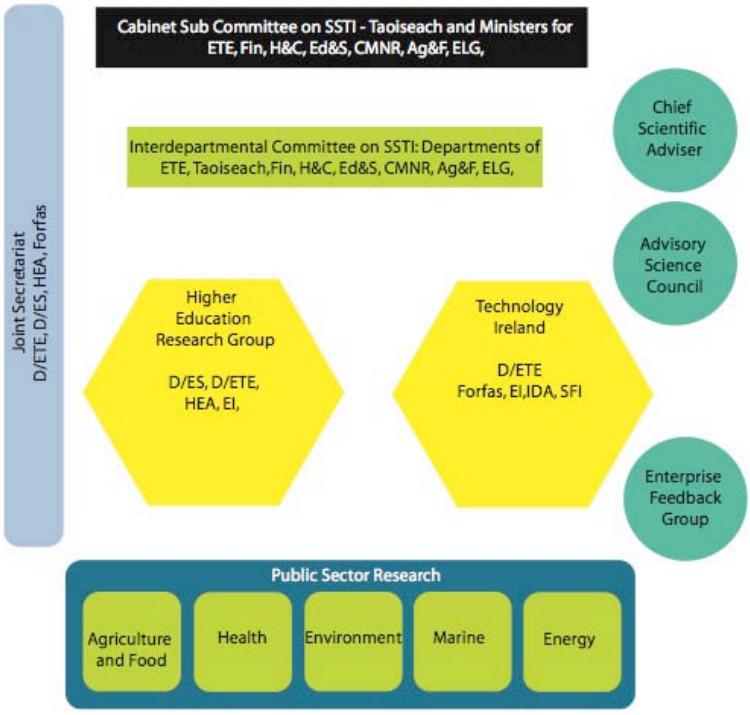

Figure 3.4: Implementation of Irish SSTI

wards incentives for knowledge-based activity such as research and development (R&D)—so one could now say Ireland has established a framework for "innovation by invitation" as argued by Roper and his colleagues [O'Malley et al., 2006, p. 51] with the groundwork analysis in the context of an all-island analysis of economic development (i.e. Northern Ireland and the Republic of Ireland) [Roper and Frenkel, 2000] .

The advantages of Ireland for FDI, and thus the reasons for Ireland's recent economic success are usually cited as some combination of the following factors:

- Low corporation tax rate of 12.5%;
- English speaking culture (attractive to US investors);
- Positive attitude in government and among the people towards Europe and its institutions;
- Membership of the Eurozone (unlike UK including Northern Ireland);
- Educated workforce (particularly through the expansion of HE in the 1990s to over 50% participation in tertiary level education), plus a well established diaspora (earlier waves of emigration from Ireland to the UK, US and elsewhere) to draw returning workers from, plus immigrants from other EU states (most recently from the expansion of the EU to 27 member states), plus many high-skilled but not working women—culminating in a varied and well educated workforce;
- Stable democratic political environment (ironically Ireland is one of oldest democracies in Europe, as the Second World War II interrupted many of the democratic systems on the continent);
- Stable industrial relations environment underwritten by a "partnership process" (involving key stakeholders such as unions and employers' representatives in long term national plans with pay restraints);
- 'Globalised' society—outward looking, happy to travel, happy to see themselves as part of something bigger, happy to welcome foreign investment;

The reason for outlining these issues is to illustrate the broader context for research and innovation in Ireland. Despite a booming economy there have been relatively few linkages between research in the higher education sector and the main economic players in this success: the pharmaceutical research driving that sector is carried out outside Ireland; the ICT research driving the success in that sector is carried out outside of Ireland. So despite having a dynamic economy, and much innovation and improvement in productivity, and it could be argued an

emerging entrepreneurial culture, Ireland does not have a strong history of driving the success in research and development (certainly from within Irish higher education). For example, Ireland has no equivalent of Nokia in Finland—an indigenous industrial world leader linked to national university research and development.

Given that most FDI came from US-based multinationals, it can be seen that Ireland's role has been to act as a bridge between the US and Europe. The phrase that captures this best is probably Mary Harney's comment, as the Tánaiste (deputy prime minister) and Minister for Enterprise, at a meeting of the American Bar Association in the Law Society of Ireland, Dublin on 21st July 2000: "Geographically we are closer to Berlin than Boston. Spiritually we are probably a lot closer to Boston than Berlin." [Harney, 2000].

The exposure of many Irish workers to the well developed systems of multinationals, within Ireland and abroad, has created a higher tier of workers who have the skills to become entrepreneurial themselves. Thus in Galway in the mid-1990s when DEC (Digital Equipment Corporation) laid off many workers, it led to a mini-boom of spin-out activities rather than an economic disaster; similarly in the mid-2000s Motorola pulling out of Cork has led to a fresh set of innovative telecommunications companies. More commonly, but less visibly, senior workers have left multinationals to start new companies and feed into the indigenous economy. Thus one way Ireland has used multinationals as a training ground for its personnel. This is one reason why Ireland has been able to become an entrepreneurial economy in just 15 years—Ireland has educated people at the multinationals' expense (and at the Irish taxpayers' expense in terms of tax breaks). So there is a healthy emerging indigenous software sector, for example, ironically mainly targeting the US as an external market. Ireland's best successes have been in the agribusiness and the financial sector; indeed these have been so successful that Irish companies in the US employ more people than US companies in Ireland.

Despite the lack of a real success story of research and development in Ireland feeding domestic economic success, economic growth has led to increased availability of funding to re-invest in the Irish research and innovation system. This is the phase in which Ireland currently finds itself, with increasing levels of investment, and some potentially mixed messages about expectations—particularly between expectations regarding economic impact, and expectations of impact in pure academic terms. This thesis analyses the documents produced by the policy makers and funding agencies (in the higher education sector), and predicts that a conflict (or maybe a readjustment) is likely to occur within the next five years if the expected economic returns on this investment are not realised.

3.6 Summary

A recent Forfás press release (August 2007) describes the current status of research and development in the Republic of Ireland from that agency's, and the Minister for Enterprise's, perspective. This is a good summary of the current situation:

> "Forfás has published its initial findings from the 2005-2006 Survey of Research and Development Performance in the Higher Education Sector which shows that the sector's R&D performance exceeded €600M for the first time—a growth rate of over 7% p.a. (in real terms) since 2004.
>
> The survey found that:
>
> Significant growth has enabled Ireland to match the R&D intensity of competitor countries. Ireland's Higher Education R&D spend of 0.4% of GNP is comparable to the OECD average and exceeds that of the EU27.
>
> The main sources of funding were:
>
> - Government Expenditure (direct and indirect);
> - EU funding through FP6 and the Research Councils; and
> - Business, individual and philanthropic funds.
>
> The principal sources of funds were Science Foundation Ireland (SFI), Enterprise Ireland, the Higher Education Authority, the Health Research Board (HRB) and the Research Councils.
>
> Of the University group UCC reported the highest R&D funding income of over €86M, followed closely by Trinity College Dublin (€60M), UCD (€53M) and NUI Galway (€47M).
>
> Within the Institutes of Technology group Waterford IT (€9.2M) and Dublin IT (€6.7M) reported the highest income.
>
> The numbers of researchers working in the sector increased by almost 1,150 since the last survey in 2004 to over 10,000. Since many researchers also teach, this equates to approximately 4,670 full-time equivalents (FTE's [sic]). In international terms this is equivalent to 2.2 FTE researchers per 1000 in employment, which places Ireland close to the EU27 average but with someway to go to catch the EU leaders where the average is closer to 3.0 FTE researchers per 1,000 in employment.
>
> Minister for Enterprise, Trade and Employment, Micheál Martin said, 'By passing the €600M mark investment in R&D in the Higher

> Education sector this country has reached a milestone which will ensure that we continue to be a location for high quality jobs into the future. The Government is fully committed to continuing investment in this sector. As our third level institutions become major centres of research it is our hope that they will also continue to forge strong links with the private sector.'
>
> Commenting on the survey results Martin Cronin, Chief Executive, Forfás said, 'Economies at Ireland's stage of development depend heavily on R&D activity, in both the public and private sectors, to enhance their knowledge, human and enterprise capital. The trends identified in this report are very encouraging and with the commitment of Government to expanding funding through the new Strategy for Science Technology and Innovation (including PRTLI 4) and NDP commitments we can expect further expansion in the years to come.'
> "
>
> [Forfás, 2007]

It is interesting that both the minister and the Head of Forfás choose to emphasise heavily the links between R&D and the economy. The Minister "hope[s] that [the higher education sector] will also continue to forge strong links with the private sector;" the head of Forfás notes that "Economies at Ireland's stage of development depend heavily on R&D activity." Thus the assertion in this thesis, based on an analysis of how the funding systems actually operate detailed in the subsequent chapters of this thesis: that if these industrial linkages fail to materialise due to the structure of the research funding systems, the potential disconnect between the economic justification and the actual implementation will become more visible.

Chapter 4

Theoretical Framework

4.1 Introduction

The main focus of this chapter is to present an overview, and an analysis of, the relevant theoretical academic framework evidenced in the literatures surrounding models of the science, technology and innovation system. This chapter finishes the contextual framing of the thesis that was begun in Chapter 2 *A Framework for the Research Questions*, and continued in Chapter 3 *The Irish Innovation System*.

The chapter presents two views of research and innovation. One view, the traditional one in most R&D policy, is the linear model, that assumes a linear flow of ideas from basic research establishing new fundamental models, through application of these models to a specific problem domain, on to commercial exploitation of the possibilities that this application enables. Whilst it not coherently articulated as a single alternative view, there are a number of strong theoretical models that all agree with their criticism of the linear model. These non-linear models range from academically focused (Mode-2), through economically focused (National Systems of Innovation), and include a third that potentially crosses this boundary. Thus, whilst one cannot argue that these non-linear models are directly complimentary, one can say with certainty that they are all clear on the deficiencies of the traditional linear model.

4.2 Linear Model of Research and Innovation

A previous chapter (c.f. Section 2.3.1) discussed Stokes' view [Stokes, 1997] of how influential Vannevar Bush's [Bush, 1945] paradigm of R&D, research and development, has been. Stokes' argument is that Bush created (or popularised)

Table 4.1: Taxonomies of Research

J. Huxley (1934)	background, basic, ad hoc, development
J. D. Bernal (1939)	pure (and fundamental), applied
V. Bush (1945)	basic, applied
Bowman (in Bush, 1945)	pure, background, applied and development
U.S. PSRB (1947)	fundamental, background, applied, development
Canadian DRS (1947)	pure, background, applied, development, analysis and testing
R. N. Anthony	uncommitted, applied, development
U.S. NSF (1953)	basic, applied, development
British DSIR (1958)	basic, applied and development, prototype
OECD (1962)	fundamental, applied, development
Note: PRSB =President's Scientific Research Board; DRS =Department of Reconstruction and Supply; NSF =National Science Foundation; DSIR =Department of Scientific and Industrial Research; OECD =Organization for Economic Cooperation and Development.	

[Godin, 2006b, p. 650]

the concept of a linear model of innovation flowing from basic research (conducted without any applied aim in mind, and with a view towards a fundamental understanding of phenomena, largely based in academia), through applied research (conducted with an emphasis on pragmatic problem solving, and linked to industry), to industrial development. This model has then served as the dominant paradigm for researchers and policy makes from 1945 until the present day.

In perhaps the most comprehensive analysis of the origin of the linear model to date Godin [Godin, 2006b] argues, in a paper entitled "The Linear Model of Innovation: The Historical Construction of an Analytical Framework," that although Bush made important contributions to the debate, particularly on basic and applied research, and is often credited with having established this model, that the linear model of research and innovation had its origins much earlier. Godin traces the development of the linear model through three phases:

1. *Basic and Applied Research:* These definitions were initiated with the work of Huxley [Huxley, 1934], and Bernal [Bernal, 1939] and adopted and promoted by Bush. This stage in the development of a linear model saw the establishment of a clear distinction between basic and applied research, with an implication of a linear relationship (ideas flowing from basic to applied).

2. *Development:* Godin argues that analytical and statistical factors combined

to define a third term, closer to industry, of "development" of new products and processes. This is termed "experimental development" by the OECD [OECD, 1963] for example. This expanded the linear model so that ideas flow from basic research, through applied research, and on to development (with some variation in the terms used for these, see Table 4.1). These became the core definitions by which statistical data were gathered on R&D in Canada [Canadian DRS, 1947], the US [National Science Foundation, 1953], and subsequently all OECD countries [OECD, 1963], as discussed in Section 2.3.

3. *Production and Diffusion:* The final stage in the development of the linear model was when the model was extended to embrace non-R&D activities such as production and diffusion, beyond development. This extension embraced a number of evolving models of innovation, merging an innovation-centric view with a research-centric view into an integrated linear model of research and innovation; the newer OECD/EuroStat metrics for innovation were discussed in Section 2.2.2.

Godin summarises his view of the development of a taxonomy for research in Table 4.1. His paper also provides a useful history of the parallel developments in the taxonomies of innovation [Godin, 2006b, p. 658].

One of the goals of the thesis is to identify where these various theoretical and academic models have had an impact on Irish Science, Engineering and Technology (SET) policy to date, in particular as many of these theories focus on the core research question, i.e. on the importance of contextualising science. The baseline view, the linear model, though of disputed origins, is clear in its form. It can be identified by any text implying that innovation flows linearly from basic research through applied research and onto various forms of commercialisation. It can also be implied by the simplistic use of the terms basic research and applied research in a way that implies a linear relationship between them. Finally it can be explicitly mentioned as the "linear model", or cited with a direct reference to Vannevar Bush or others who have espoused the linear model.

4.3 Systems Approach: National Systems of Innovation

As was discussed in the previous section, the traditional linear model of research and development has been augmented, most notably in the 1980s and 1990s, with an innovation spin, as the generic outputs of the basic research, and their transformation through applied research into useful products and methodologies have been seen as key drivers of economies based on innovation.

This section examines the key concept of National Systems of Innovation (NSI) also known as National Innovation Systems (NIS)[1] that encapsulates this revised model. In systems approaches to innovation there is often a focus on a sector (e.g. biotechnology), or on a region (either within a country or spanning national boundaries, e.g. all-island for the Republic of Ireland and Northern Ireland), but the pragmatic emphasis continues to be a national one, based on the fact that most developed countries have national legal powers to instigate national policies. Those espousing a NSI view would usually argue that the systems approach is non-linear, examining the interrelationships between all the entities involved in innovation (organisations and their relationships). The NSI approach is often seen as inspired by evolutionary economists, and the NSI theory itself supposes that the these systems evolve over time.

The term Science, Technology and Innovation (STI) is common in the literature of polices relating to research in science and technology (as discussed in Section 2.2.2). In particular, the entities involved in basic and applied research, and in research and development, are described as being part of a National System of Innovation. This new terminology and analysis was pioneered in the late 1980s and early 1990s primarily by Freeman [Freeman, 1987], Lundvall [Lundvall, 1992] and Nelson [Nelson, 1993]. All three contributed chapters to a section entitled "National Systems of Innovation" in Dosi's book [Dosi et al., 1988]. In many ways these descriptions do not alter the fundamental model of what science and research are, but harness them in a model focused on the industrial exploitation of their outputs.

A good overview of this area has been articulated by Edquist [Edquist, 1997, 2001]. As well as surveying the state of the art, he defines a common set of terminology (commenting on incompatibilities between different authors and within the same author), starting with the definition of a system:

> "there is, however, a common answer in everyday language as well in scientific contexts:
>
> - A system consists of two kinds of entities: There are firstly, some kinds of components and secondly, there are *relations* between these.
> - There should be reasons why a certain array of components and relations has been chosen to constitute the system; they form a *whole*.
> - It must be possible to discriminate the system in relation to the rest of the world; i.e. it must be possible to identify the

[1] In this thesis the former term is preferred, and the latter is only used when in a quotation from another source.

> *boundaries* of the system. However, only in exceptional cases is the system closed in the sense that it has nothing to do with the rest of the world. That part of the rest of the world that in some sense is important for the system is called its *environment*. (Ingelstam 2000: 9)"
> [Edquist, 2001, p. 4]

And similarly in the same text providing a definition of an organisation and an institution:

> "*Organizations are formal structures with an explicit purpose and they are consciously created* ... They are players or actors. Some important organisations in SIs are companies (which can be suppliers, customers or competitors in relation to other companies), universities, venture capital organisations and public innovation policy agencies. *Institutions are sets of common habits, routines, established practices, rules, or laws that regulate the relations and interactions between individuals, groups and organisations* ... They are the rules of the game. Examples of important institutions in SIs are patent laws and norms influencing the relations between universities and firms."
> [Edquist, 2001, p. 4]

Whilst it may seem confusing to define "institutions" as Edquist does, to mean established practices of interactions between individuals, groups and organisations, he does however propose a consistent set of definitions overall.

Godin, in a paper that focuses on an analysis of the history of the concept of the knowledge-based economy, suggests that there are two parallel families of authors in the National System of Innovation umbrella:

> "There are two families of authors in the NSI literature: those centering on the analysis of institutions (including institutional rules) and describing the ways countries have organized their NSI (Nelson, 1993), and those who are more "theoretical", focusing on knowledge and the process of learning itself: learning-by-doing, learning-by-using, etc (Lundvall, 1992). From the latter group, the concept of the knowledge economy re-emerged."
> [Godin, 2006a, p. 18]

Godin clearly identifies the link between the OECD and the NSI approach in terms of the key player Lundvall:

> "It was to Lundvall—nominated deputy director of the OECD Directorate for Science, Technology and Industry (DSTI) in 1992 (until 1995)—that the OECD Secretariat entrusted its program on NSI. In fact, the OECD always looked for conceptual frameworks to catch the attention of policy-makers. In the early 1990s, it was NSI that were supposed to do the job: getting a better understanding of the significant differences between countries in terms of their capacity to innovate, and looking at how globalization and new trends in science and technology affect national systems (OECD, 1992, 1994b, 1996d). From the start, the OECD program identified the construction of indicators for measuring NSI as a priority (OECD, 1993b), and indeed early on suggested a list of indicators to this end (see Appendix 1) (OECD, 1997b). But the decision to build on existing work because of budgetary constraints (OECD, 1992, p. 10) considerably limited the empirical novelty of the studies. Nevertheless, the program, conducted in two phases between 1994 and 2001, produced several reports that looked at flows and forms of transactions among institutions, among them: clusters, networks, clusters, and mobility of personnel (OECD, 1995a, 1997b, 1999a, b, 2001a, b, 2002a). The program did not have the expected impact on policies, however. In a recent review paper, the OECD admitted: "there are still concerns in the policy making community that the NIS approach has too little operational value and is difficult to implement" (OECD, 2002a, p. 11)."
> [Godin, 2006a, pp. 18–19]

In 1997 the OECD published an overview of *National Systems of Innovation* that cited the main authors such as Freeman, Nelson and Lundvall. This document discusses the difference between the innovation systems model and the linear model:

> "The national innovation systems approach also reflects the rise of systemic approaches to the study of technology development as opposed to the "linear model of innovation". In the linear model, knowledge flows are modeled quite simply: the initiator of innovation is science and an increase in scientific inputs into the pipeline will directly increase the number of new innovations and technologies flowing out of the downstream end. In reality, however, ideas for innovation can come from many sources and any stage of research, development, marketing and diffusion. Innovation can take many forms, including adaptations of products and incremental improvements to processes."
> [OECD, 1997, p. 11]

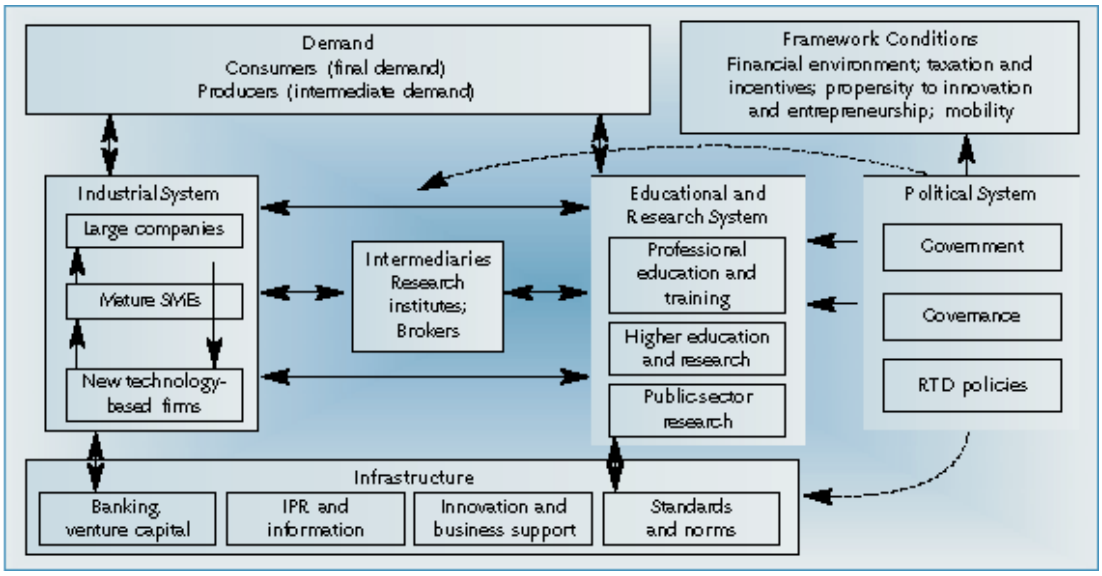

Figure 4.1: Model of a National System of Innovation

Thus it is clear that the basic NSI model is by definition non-linear in how it views the innovation process.

Figure 4.1 shows a typical NSI model, from an analysis of the Research Council of Norway [Arnold and Kuhlman, 2001, p. 13]. This shows the relationships between the academic and industrial players, breaking these down into different types of entities, and also a rich set of other elements such as the regulatory frameworks, and financial systems. The important thing from an NSI perspective is that it is not sufficient for the overall health of the system for the individual actors to perform well, it is also a requirement that the links between them perform well. "In contrast to earlier views, which focused on entrepreneurs as individual heroes, innovation and learning are now seen more as network or collective activities" [Arnold and Kuhlman, 2001, p. 13].

The argument of NSI is that each national area should do detailed analysis of the health of its own NSI, and then target measures aimed at improving any deficiencies, in the types of actors or their ability to perform, and in the types of networks that link the actors together and allow ideas to flow in complex ways through the network of actors.

In Section 4.6 below the relationship of NSI to the other theories is discussed in detail. Reference to the NSI theory can be identified by explicit reference to NSI or NIS and by citation of the key figures such as Nelson, Freeman, and Lundvall. Regional or sectoral views of systems of innovation are effectively very similar, part of a family of systems of innovation approaches.

4.4 Gibbons' Model: Mode-2 Science

Gibbons, Limoges, Nowotny, Schwartzman, Scott, and Trow [Gibbons et al., 1994] in their book on new modes of knowledge production are the main proponents of an alternative non-linear view of knowledge production. This book introduced the concepts of Mode-1 and Mode-2 knowledge production, the former being founded on traditional discipline-based research, and the latter being much more transgressive taking meaning from the applied context and engaging in dialogue with society.

Gibbons et al. have described Mode-2 knowledge production as having four identifying features:

- that it is generated in the context of an application (i.e. that it only makes sense in an applied context);
- that it is transdisciplinary, living a world of flux where new disciplines might exist for the duration of the development of a solution to a particular problem;
- that this knowledge production can take place in a very diverse set of locations, not only in traditional universities and research laboratories;
- that it is a highly reflexive process, where the revaluation of the processes involved by the participants themselves is an important part of the process.

Thus Mode-1 dominates academic institutions today. Here new disciplines evolve over decades, and establish the supporting structures of well-known journals, with editorial peer review processes, academic departments, professional societies, and other mechanisms for the discipline to maintain itself. In this world disciplines such as Computer Science are relative newcomers, and the discipline of Medicine is well established. The traditional disciplines can be dated back to the classical world or Greece and Rome, that then became part of the core curriculum of medieval universities. More recent disciplines, and the primary disciplines of science itself, emerged in the 19th Century as the university system changed to support industrialisation.

In contrast Mode-2 operates where new disciplines are created for the duration of a project often focused on attempts to solve a problem, and often bringing together people from various Mode-1 disciplines, hence the key term transdisciplinary). Here it becomes problematic deciding what academic department is the most suitable to host a relevant course, or what journal to publish potential results in, as these Mode-1 structures cannot adapt fast enough to the dynamic nature of Mode-2. This makes it more difficult to evaluate the Mode-2 activity.

In addition the actors involved are more often from outside of academia, perhaps coming directly from an applied industrial context.

Mode-2 does not replace Mode-1, but grows and thrives around the existing Mode-1 structures. Individuals, especially academics, may be involved in both types of activity. Mode-2 essentially breaks down the barriers that have been developed, particularly in the 20th Century, to isolate science from society, and to allow knowledge production to be carried out in a separate space. Thus it can be seen as a model for the pressures now placed upon universities to integrate more into society.

In later writings the authors have addressed the extent to which their earlier theories have been reinterpreted and adopted by certain groups in society, particularly policy makers attempting to justify innovation policies; researchers in disciplines not fully recognised as scientific, such as the professions; researchers in newer universities without the established traditions of the higher educational elite [Nowotny et al., 2003].

The authors are also keen to explain that their Mode-2 knowledge production theory has been simplified and abused, to some extent, and seen as a simplistic justification for applied research over basic research [Nowotny et al., 2003]; in contrast they claim their theory was much more subtle and complex, suggesting that the terms applied and basic research no longer have relevance, and that the contextual environment has changed so much that a complete re-evaluation of the modern scenario is required.

In their more recent work, and in particular in the follow-on book *Re-Thinking Science* [Nowotny et al., 2001] the originators, technically a subset of them, of the new production of knowledge thesis recognise that they may have underplayed the key role of the link to society in their original statement of the thesis. In fact they go on to say the modern scenario can now be viewed as an interaction of Mode-2 knowledge production with a Mode-2 society, a combination of science and society that is now fundamentally different than it was before because of the influence of science on society, and now of a feedback from society to science. Forcefully, in their reiteration that their model is more than a defence of applied research, [Nowotny et al., 2001, p. 199] declare that "the epistemological core is empty—or, more accurately, that the epistemological core is crowded with many different norms and practices which cannot readily be reduced to generic methodologies"; they remind us that science was always about a methodology for establishing truths, more than being about the truths themselves.

Although few of those who utilise the Mode-2 argument are brave enough to tackle this stark message head on, it is interesting to note the extent to which Mode-2 papers have been cited by various institutions around the western world to justify STI policies. Mode-2 arguments have been used to justify institutions that

are weaker academically, one example being its use by new Australian universities as an argument for higher status [Ronayne, 1997].

Perhaps the most common mis-representation of Gibbons et al. is the simplification that Mode-1 is basic research and Mode-2 is applied research. Thus, Gibbons is often used to support newer higher level institutions that have a more vocational or applied ethos with a claim that Gibbons et al. support the refocusing of research priorities from basic research towards applied research. The problem with this simple view is that the applied sciences are structured in the same domain-centric structures as the basic sciences, thus being organised along Mode-1 lines. Gibbons himself is very clear that Mode-2 is not the same as applied science:

> "Research carried out in the context of application might be said to characterise a number of disciplines in the applied sciences and engineering - e.g. chemical engineering, aeronautical engineering or, more recently, computer science. Historically these sciences became established in universities but, strictly speaking, they cannot be called applied sciences, because it was precisely the lack of the relevant science that called them into being. They were genuinely new forms of knowledge though not necessarily of knowledge production because, they, too, soon became the sites of disciplinary-based knowledge production in the style of mode 1. These applied disciplines share with mode 2 some aspects of the attribute of knowledge produced in the context of application. But, in mode 2 the context is more complex. It is shaped by a more diverse set of intellectual and social demands than was the case in many applied sciences while it may give rise to genuine basic research."
> [Gibbons, 1997, p. 4]

Arguably, the research question discussed in Chapter 2 is very close to Nowotny, Scott and Gibbons' observation:

> "Of course, it is relatively easy to describe the ongoing process of contextualization in different research fields, by pointing to shifts in research agendas and how research priorities are set, and describing how the policies of research councils and other funding agencies are articulated and directed towards certain objectives, most of which follow the fuzzy contours and reflect the vague contents of the so-called Knowledge Society (or, at least, a knowledge-based economy)."
> [Nowotny et al., 2001, p. 56]

This use of "contextualization" is the same usage as the core research question and ties in directly to the terminology used in this thesis. Clearly the authors

believe that searching through research priorities, and policies of research councils and funding agencies, would lead to evidence of contextualisation. In Chapter 5 the methodology for this thesis is discussed in detail, including the selection of the corpus of public documents to be analysed, and the method of reading to search for evidence of contextualisation.

4.5 Etzkowitz's Model: Triple Helix

The Triple Helix model can be viewed as deriving from the general NSI type of approach, though it considers itself as significantly different in terms of its analytical framework, and its focus is not on the firm as leading innovation, but on the network overlay of communications and expectations that link the actors in the innovation system. The Triple Helix is founded on the complex interrelationship between three types of actor: government, industry and universities. The concept is that "The dynamics are nonlinear while both the interaction terms and the recursive terms have to be declared" [Etzkowitz and Leydesdorff, 2000, p. 113]. So, there exists a complex non-deterministic system of interactions between three types of entity out of which arise research results. The implication is that universities take on actively, but in many different and complex ways, the role of directly contributing to the economy, rather than focusing on pure academic research. The model is flexible enough to cope with variations, which have been described in terms of three types of Triple Helix each of which may be more relevant to different national and regional contexts.

> "The 'triple helix' is a spiral model of innovation that captures multiple reciprocal relationships at different points in the process of knowledge capitalization. The first dimension of the triple helix model is internal transformation in each of the helices, such as the development of lateral ties among companies through strategic alliances or an assumption of an economic development mission by universities. The second is the influence of one helix upon another, for example, the role of the federal government in instituting an indirect industrial policy in the Bayh-Dole Act of 1980. When the rules of the game for the disposition of intellectual property produced from government sponsored research were changed; technology transfer activities spread to a much broader range of universities, resulting in the emergence of an academic technology transfer profession. The third dimension is the creation of a new overlay of trilateral networks and organizations from the interaction among the three helices, formed for the purpose of coming up with new ideas and formats for high-tech development." [Etzkowitz, 2002, p. 3]

Etzkowitz argues that such a model, with three overlapping spheres of influence representing universities, government and industry, typify the emerging norm in the USA, where this has been a bottom-up development, and in Europe, where it has resulted from a more top-down approach with specific national and European policies creating an innovation environment. As is usual when proposing a model that is potentially simplistic and limiting, he argues that different forms of the model may co-exist within a country at the same time.

In more recent papers he has emphasised the way that the different actors can take on the form of each other:

> "Triple Helix (Etzkowitz & Leydesdorff, 2000) argues that increasing linkages and interaction between university, industry and government facilitates technology transfer from university to industry. In addition to increasing linkages and interaction, this model argues that each actor assumes the role of other. Thus, universities assume entrepreneurial tasks such as commercializing inventions or forming start-up companies. Companies take on academic roles such as sharing knowledge among each other and with universities; government takes the role of venture capitalist. Hybrid organizations are also invented in the transition from statist (1) and laissez-faire (2) triple helix regimes to one of overlapping, relatively independent spheres in which each maintains its primary purpose while also taking the role of the other."
> [Etzkowitz and Goktepe, 2005, p. 2]

In general the Triple Helix model has often been harnessed by proponents of an entrepreneurial university, such as Etzkowitz himself.

There has been some debate as to whether the Triple Helix is a model, a metaphor or reality. Leydesdorff and Etzkowitz themselves are clear: "In our opinion, the Triple Helix is mainly a model for analyzing innovation in a knowledge-based economy" [Leydesdorff and Etzkowitz, 1998].

Reference to the Triple Helix model can be identified by an explicit reference to the model, or to the two key authors Etzkowitz and Leydesdorff.

4.6 Discussion

All of the new models are a response to the simplistic linear model described first. So all of the other models are non-linear in one form or another. This is highly significant. This thesis will in one sense group all three of the new models together in opposition to the traditional linear model. The nuance of how one analyses the complex interactions that make up a non-linear system, and

how these new models may differ, is less important than the fact that one has to do this. From a policy making perspective, as a justification for investment in R&D, accepting any one of the non-linear models means that one cannot simply provide funding for basic research in HEIs and expect the system as a whole to operate. Instead one must understand the complex interrelationships and motivations driving relationships between the academic institutions (and the permanent and contract researchers and students), the industrial companies (and the researchers there, and the product managers and others there), and the public sector funding agencies and government departments (and the civil servants, and project officers, and funding programme processes). Simply increasing funding will not necessarily promote a rich research and development ecosystem. One has to build capacity where it cost efficient to do so. One has to nurture relationships and networks, without making these simply reliant on public funding to exist. One has to coordinate the priorities and incentives across the range of funding agencies and ensure that they are complementary and not counter-productive. This task requires a detailed analysis of the existing structures in the national context, and a detailed study of what works and what does not. In this sense the Mode-2, NSI and Triple helix models agree—the bigger complex system is what counts. Mode-2 is perhaps the least operationally relevant of the theories, though still very articulate and thought provoking. All of the models highlight the extent to which really novel and innovative activity happens completely outside of HEIs 9as well as within HEIs as it always has done), and so any system that assumes that all such activity happens only within HEIs is lacking.

All the new models were promoted heavily in the 1990s, with NSI being the older (pre-dating the 1990s), Mode-2 starting from 1994, and Triple Helix appearing in the late 1990s. The NSI approach is a traditional economic one, with the implied assumption that the company has the leading role in innovation. The Mode-2 model focuses on issues relating to academia and the production of knowledge, rather than on innovation itself. The Triple Helix model is posited as a conscious evolution from the previous two models so that it "provides a model at the level of a social structure for the explanation of Mode 2 as an historically emerging structure for the production of scientific knowledge." [Etzkowitz and Leydesdorff, 2000, p.118]. Similarly, the Triple Helix model questions whether national systems are the the relevant unit of analysis, preferring to allow for multi-national, national and regional analyses.

Shinn [2002] using bibliometrics and other analyses, has looked at the prevalence of various theories of research and innovation, and at the influence and impact of these various theories of knowledge production on the world stage. He clearly identifies the Triple Helix as being popular in developing countries (Latin America, Asia and Africa), and Mode-2 as being popular in Western Europe, the

USA and Canada. "Based on the institutional affiliations of citing authors and individuals attending relevant meetings, over 90 percent of the New Production of Knowledge audience is based in the North, as against about 65 percent of the Triple Helix (the latter count is based on participation in conferences). The Triple Helix thus enjoys a sizable following among the developing countries." [Shinn, 2002, p. 602]

Shinn then discusses the different nature of Triple Helix and Mode-2 models, and relates this to National Systems of Innovation. He argues that Mode-2 is an argument that touches on many spheres (education, business, politics) and that this has led it to be viewed as some sort of magical solution to problems by many in these spheres. On the contrary, "'The New Production of Knowledge' and 'Re-Thinking Science' do not define questions, set forth a methodology, provide reasoned answers, or set limiting conditions. On the contrary, they can be likened to political manifestos, whose expository form is rhetoric" [Shinn, 2002, p. 610].

Shinn goes on to analyse the Triple Helix model, arguing that "The socio-cognitive field of the Triple Helix is very different. When measured in citations, its audience is negligible. But if gauged by reference to international meetings and developing nations, the Triple Helix mobilizes a large number of followers. The Triple Helix may or may not constitute an analytic model, but it does constitute a serious research school with an empirical and conceptual agenda" [Shinn, 2002, p. 610].

Shinn finally argues that both Mode-2 and Triple Helix should take greater account of Nelson's work on National Systems of Innovation, as this "still accounts for much of science/industry/government dealings" [Shinn, 2002, p. 611].

Sharif [2006] agrees that NSI has been neglected in the Science and Technology literature. His article addresses the deficit by analysing NSI from a social constructivist perspective, basing his views on interviews with many of the key players, and describing the evolution of NSI in the words of they key players in its evolution.

> "Similar conceptual tools that have received attention for their roles in science and technology policy from an S&TS standpoint are the 'New Production of Knowledge' approach of Gibbons (1994) and the 'Triple Helix Model' (Etzkowitz and Leydesdorff, 1997, Etzkowitz and Leydesdorff, 1998 and Etzkowitz and Leydesdorff, 2000). In contrast to the NIS concept, these perspectives have been debated and discussed broadly in S&TS (see, for example, Hicks and Katz, 1996, Godin and Gingras, 2000, Ziman, 2000, Cohen et al., 2001, Jansen, 2002, Shinn, 2002 and Pestre, 2003). This neglect of the NIS concept in the S&TS literature is somewhat surprising because, although the NIS perspective is not yet as influential as Gibbons's 'New Pro-

> duction of Knowledge' approach, it seems to exhibit the institutional trappings and claim as many adherents as the 'Triple Helix Model'."
> [Sharif, 2006, p. 747]

Whether or not we are prepared to believe in any or all of these new theories of science, and in the interactions between science and society, the basic premise that the post Cold War western society has been in the process of dynamic change in its attitudes to science, technology and innovation does indeed seem to be prominent in the academic literature.

In a chapter in the recently published *The Oxford Handbook of Innovation*, Mowery and Sampat present a review of models of research and innovation and select the main three theoretical models discussed here (national innovation systems, Mode-2 and Tripe Helix) as the current leading models, but criticise these theories as not yet being mature enough to have easily understood metrics for their application to specific scenarios.

> "The 'national systems,' 'Mode 2,' and 'tripe helix' frameworks for conceptualizing the role of the research university within the innovation processes of knowledge-based economies emphasize the importance of strong links between universities and other institutional actors in these economies. ... What is lacking in all of these frameworks, however, is a clear set of criteria by which to assess the strength of such linkages and a set of indicators to guide the collection of data."
> [Mowery and Sampat, 2006, p. 214]

However, no alternative developed model is presented; instead the argument is for the development of further metrics to help the use of these models consistently. The paper itself focuses on the existing available data to make high level comments on how university-industry interaction is evolving in different parts of the world.

Rip [2000] is cynical about the value of these new models, but Mode-2 and the Triple Helix are identified, along with some of the earlier work of the Triple Helix author Etzkowitz[Rip, 2000, p. 45].

> "Change must be in the air, given the popularity of phrases such as Mode 2 knowledge production (Gibbons et al.,1994), the second academic revolution (Etzkowitz, 1990:1998), and Triple Helix (Etzkowitz & Leydesdorff, 1997). However correct the diagnoses of the state of knowledge production implied in these phrases might be, these phrases are also rhetorical ploys."
> [Rip, 2000, p. 45]
> "If Mode 2, with its emphasis on non-disciplinarily and discovery in

> the context of application, has been there all the time, why the sudden interest? Taking a page out of the (severely underdeveloped) sociology of fashions in science policy, I would argue that the Mode 2 thesis has become so popular (at least with science policy makers) because (i) it names a feature of science which has become more relevant, (ii) it creates an occasion for policy making, and (iii) it feeds the need for mimesis in science policy making."
> [Rip, 2000, p. 46]

Whether one agrees with Rip or not, it is clear that he believes that Mode-2 and Triple Helix are being talked about, and that the Mode-2 thesis is very popular, especially with policy makers.

4.7 Summary

This chapter has analysed an intense debate in the academic literature as to the changing nature of science and technology in the modern world, and in particular the place of the research university (or equivalent institution) in the knowledge production and innovation process. To simplify a complex debate, the older assumed model and the three most challenging and potentially most influential of the new proposed models to explain what is happening are:

Linear Model dating back to Bush after World War II, if not or earlier;

National Systems of Innovation Model pioneered by Lundvall and Freeman from the early 1980s onwards;

Mode-2 Model dating to Gibbons et al. in 1994; and

Triple Helix Model dating to Edquist in the late 1990s.

These four models will be discussed in most detail in subsequent chapters, and in particular evidence will be sought for references to these models in the Irish policy literature. The last three models are all explicitly non-linear, and so from a high-level perspective this thesis is focused on one linear model and three complimentary non-linear ones, rather than just four separate models.

Chapter 5

Design and Methodology

This chapter describes the methodology used in this study of policy documents. The thesis is an exercise in a structured reading of policy documents and related texts informed by a complex contextual framework made up of the academic theories from related domains and the actual innovation system in Ireland and its players.

The case for documentary analysis is placed within a wider context of linguistics (the formal study of language), and of related humanities disciplines (e.g. history) where analysis of documentary sources is key, and relates these issues to the work of social science methodology on the use of textual analysis. Within the social science domain there are specific problems that arise with policy documents, given the nature of their creation. This discussion establishes the context for the detailed presentation of the methodology and method used in this thesis.

The chapter describes in detail the process used to select the texts being studied, and then outlines the reading framework used for the analysis presented in the subsequent two chapters.

5.1 Discussion of Documentary Analysis

In one sense all formal written research includes large elements of documentary analysis, in that situating all academic research in the context of the related academic literature, ideally peer-reviewed, is considered a basic component of academic writing, and of the academic quality process. Authors are not required to necessarily describe their methodology for this separately, though there is a small but growing literature on how to formally study academic literature. Thus, in some senses, all academic research involves documentary analysis, though the nature of this is not normally foregrounded. However, when the primary data

being used by a researcher in a thesis or an academic paper is based on an analysis of texts or documents, some description of the research methodology employed is necessary. This chapter serves that function for this thesis.

The discussion here begins with some basic linguistic principles, and then examines how linguistic theory has influenced social science documentary analysis techniques.

Even a cursory reading of the literature on linguistics shows that any engagement with texts is a problematic exercise. Ambiguity is a core part of natural language, and making sense of ambiguity involves semantics that go well beyond what is written in a text, and move towards the way knowledge is formulated by individuals and is used to contextualise any text being read. Thus, in effect, all texts have multiple meanings, that can change over time.

An early influential contribution to the linguistic discussion of language was the Sapir-Whorph hypothesis [Sapir, 1929; Whorf, 1940], that held that one's own natural language could potentially constrain one's thoughts, i.e. that speakers of different languages thought differently, that language and thought were directly linked — one thought only in language.

The core concepts of modern linguistics were defined by Saussure at the start of the 20th century [Saussure, 1983] (this book is based on notes taken from his lectures at the University of Geneva between the years 1906 and 1911 and was published in 1916 after his death). He held that the symbols used in writing, or the sounds used in speech, effectively composed a system of signs where each sign was made up of a signifier and a signified, and that the link was fundamentally arbitrary. Thus a word (signifier) is linked to a concept (signified), and it is only by some common agreement on this link, and some common agreement as to what the concept being signified is, that communication is possible. Language then places these core signs into larger syntactic structures that can convey richer meanings. Arguably this approach leads directly to the attempts to formally represent linguistic semantics through well-defined grammars as instigated by Chomsky [Chomsky, 1956], one of the primary directions linguistics has taken in the past fifty years.

Alternative approaches to understanding the semantics of language are often characterised as being influenced by a functional perspective — how language is used to communicate, and the meaning can be linked to the actions that are initiated as a result of language. The philosopher Searle, and his definition of the concept of *Speech Acts* is considered one of the main founders of this approach [Searle, 1969]. In a sense social science discourse analysis derives from this type of approach.

Compared to some other forms of method used in educational and social science research, comparatively little has been written on the analysis of text and

spoken language. This has been observed both by Tight in his own a short two-page overview of the literature on documentary analysis, as relevant to research on higher education [Tight, 2003, pp. 188–189], and by May in his longer discussion in a more general text on social research [May, 2001, pp. 176-177]. So ironically the ability to read texts and construct summary analyses is perhaps one of the core academic skills, yet in terms of documented research methodologies documentary analysis is less formalised than many alternatives.

Arguably studying defined texts, compared to the direct study of a social situation, or study of spoken communications, does have the benefit of clarity in terms of well defined scoping boundaries — any word or phrase is either in the text or it is not. Of course there is much potential for flawed analysis based on simplistic assumptions. Choosing which texts should be analysed is fraught with potential selection biases, and access permission biases. Then the analysis must allow for the fact that the authors of those texts might be either consciously or unconsciously be pursuing their own biases as to what is included in or excluded from the texts themselves. And of course the way information is presented in the texts may be similarly influenced by many types of bias.

In the case of policy texts that often represent some form of consensus of a committee or of a wider group, there is often no sense of common authorship throughout the text, and so it is indeed quite normal for different parts of the document to be structured with differing biases, potentially even stating directly opposing views. It would be normal for the main editors to try and minimise obvious inconsistencies, but time constraints for the production of texts can mitigate against such normalising processes. Thus the core issue of any form of textual analysis is that any text, even the simplest of texts, written in a natural language, is open to many different understandings of its semantics. Indeed, one could argue this more strongly, by stating that the act of reading, of extracting a semantic view, is a deeply contextual one that cannot be made purely objective.

One aspect of probing the semantics may be based on an attempt to understand the intention of an author or authors (this raises one set of problems), and other aspects could be based on attempts to probe a deeper set of meanings (this raises another set of problems).

Of the published material on documentary analysis in the past ten years, May's chapter on documentary research [May, 2001, pp. 175–199] in a general book on methods for social research, and Silverman's chapter in the *Handbook of Qualitative Research*, [Silverman, 2000, pp. 821–834], are two examples aimed at researchers as practitioners of these methods in the available literature. May discusses different approaches with some examples to guide his readers. Perhaps most importantly he highlights two main critiques of documentary analysis: "the bias of documents and selectivity in their analysis" [May, 2001, p. 198] —the

former essentially being a warning against taking a document at its face value, and the latter being a warning against reading into a document what one might want to see, and failing to take into account the processes that may have produced the document. Silverman has more of a focus on speech as well as text, in his examples he discusses three main frameworks for analysis [Silverman, 2000, p. 828]:

- Harvey Sacks' analysis of membership categorisations;
- Foucauldian discourse analysis;
- Saussurian semiotics.

and favours limiting the data set and doing a detailed analysis of that data set that goes beyond mere categorization itself.

McCullogh [2004] agrees that there has been a lack of emphasis on documentary analysis in social research in the late 20th century. However, he places this in the wider context of the historical evolution of social science that made much more use of documentary analysis in the earlier 20th century, being more in tune with the discipline of history that has always been focused on documentary evidence as primary and secondary sources. He sees that social research and history have become "alienated from each other" [McCullogh, 2004, p. 28] over the course of the century as social science moved to using other methods and excluding documentary analysis itself. His book is a reminder of the acceptance of these methods in other disciplines, and of the potential wealth of material that is available and could be brought to bear to help address a wide range of research questions.

This thesis will draw on McCullogh's pragmatic reference to the utility of documentary evidence when looking for materials to help answer a social science question, as any historian could attest. In other words, McCullogh has been cited as a reminder that it is valid to use an analysis of public documents as a primary research methodology, and, although this does have some limitations, this is the approach that this thesis has adopted.

At the heart of the debates around textual analysis in recent times has been the influence of discourse analysis coming, as it does, from a literary tradition spanning the entire twentieth century including Foucault, Derrida and Barthes and its fundamental questioning of language and of meaning. This has led to a postmodernist focus on deconstructing texts: undermining the frame of reference or assumptions that underpin the text, though not all the authors listed in this paragraph would accept the postmodernist or post-structuralist labels.

Perhaps one could see the overall field of documentary analysis as forming a dispersed spectrum ranging from one pragmatic extreme of the use of the document as a tool, with the flaws it may contain, to the other extreme that sees the

linguistic analysis of the document as the core aim, irrespective of the document's genesis or its external reference. The approaches to the document can range from almost quantitative counting of instances of words or constructs, and building an analysis based on these statistics, to a sort of high level deconstruction of a text.

Fairclough [2003] provides a detailed discussion on the analysis of discourse, of which written documents form a part. Fairclough has a clear focus on what can be learned from linguistics that is of use when analysing texts formally in social science, and he includes transcripts of written conversations as a form of text. He presents a useful checklist for textual analysis, with each section linked to further discussion in the book [Fairclough, 2003, pp.191–194], highlighting a series of types of questions any analysis might ask of a text:

- Social events — analysis of how the text itself was constructed;
- Genre — how the text is situated with respect to other texts of the same type;
- Difference — whether the text attempts to highlight difference or create consensus;
- Intertextuality — explicit or implicit inclusion or exclusion of other relevant texts;
- Assumptions — existential, propositional and value assumptions of the text;
- Semantic/grammatical relations between sentences and clauses — causal, temporal and other relationships established in a text between sentences and clauses;
- Exchanges, speech functions and grammatical mood — analysis of the major types of speech functions, and grammatical mood;
- Discourses — analysis of how the discourses are drawn upon in the text;
- Representation of social events — analysis of the way social events are included or excluded, and how they are presented;
- Styles — styles as the discoursal aspect of identity;
- Modality — 'epistemic' modality and 'deontic' modality, the author's stance towards statements made through knowledge and activity exchange;
- Evaluation — the extent to which the authors commit themselves to the values in the text.

From the range of questions raised by Fairclough, the emphasis in this thesis is on a specific form of intertextuality (implicit and explicit), where direct evidence is sought for the use of well-defined and published academic models in policy texts. Thus the documentary analysis being performed is based on a reading each of the documents being analysed, looking for both

1. explicit references to academic papers and authors names associated with a set of defined models;

2. implicit use of these models without explicit reference to their origin.

Given that the academic models (the four models discussed in detail in Chapter 4: Linear and three nonlinear—NSI, Mode-2, and Triple Helix) are all strongly associated with definitive texts in which they are described, this search for models is effectively a search for intertextual references between the public policy documents and this set of literatures.

So this section has justified the method of analysing texts as being a valid research mode to study the development of a policy, as McCullogh cogently argues. This thesis will use this method to look at how the notion of contextualising SET research, binding it to industry and to society in some contextual framework, can be understood to exist or not exist in the series of texts being analysed. In additional this section has justified the use of detailed study of how the core body of texts being analysed refers explicitly or implicitly to a set of literatures around the four models of research and development described in Chapter 4, which is one aspect of the type of detailed textual study advocated by Fairclough.

The reading framework used in this thesis will be discussed in detail in Section 5.3. First there is a short discussion on the nature of policy texts in particular, and the published materials on how to analyse this particular form of text.

5.2 Discussion of the Nature of Policy Texts

This thesis has taken the approach of limiting the direct research source materials to public policy texts relating to Science, Engineering & Technology (SET) public research funding policy in the period 1995–2008 in the Republic of Ireland (Éire). It is important to place this within the wider context of how policy itself is formulated, and what it is.

Policy documents are generally public documents produced by a social process that may also itself have some public elements. Larger documents will often involve an appointed team of editors who may openly solicit contributions from the public, or from specific stakeholders. The documents are sometimes written directly by civil servants, or other public sector employees, with a policy role.

On other occasions the documents are written by professional consultants contracted to write a report. In democratic societies government decisions are often supported by a set of such open processes, and resultant policy documents, that gives some justification for the final decisions made, such as the passing of a specific Act that brings new systems legally into force, or the allocation of a public funding budget that allows certain activities to receive funding. In Ireland, as elsewhere, the key government processes are divided into ministries, each with a Minster and potentially a number of Ministers of State, also called Junior Ministers (see Section 3.1.2 for a list of Irish ministries/departments). The ministries each have a permanent civil service staff responsible for running the department, independent of whichever political party or parties are in government, and a key role of these civil servants is to gather relevant information to enable suitable decisions to be made as needed. Thus the policy documents themselves are one part of a much larger social process, and there may be important information about this process that cannot be accessed via the documents themselves. In many policy areas, such as the focus of this thesis, responsibility may be divided across a number of departments, and some management structures may be in place to allow cross-departmental processes to occur.

There is a long tradition of the formal analysis of the state, of the policy formation process in general, and of the areas of education policy, and more recently of science, technology and innovation policy. Arguably the latter is more directly relevant to this thesis than the former, and is dealt with more fully in Chapter 4, where theoretical models of research and innovation are discussed. Ireland does not have a strong tradition of published research in policy, although some notable exceptions exist [Taylor, 2005; Hughes et al., 2007]. More often Irish authors of papers about policy refer to UK, US and other sources. The tension in Ireland as a small country is that the cost of maintaining a large open process has to be balanced against its benefit. One advantage of being a small country is that in many areas it is less cumbersome to assemble representatives of key stakeholders than it would be in a larger country, so potentially faster progress can be made, whilst still remaining open and accountable. That does not mean that Ireland, as a small country, is immune from criticisms that the state prioritises policies that suit various powerful elites (e.g. privileged classes, professionals, or wealthy citizens); arguably it is easier to exert some influence on a smaller system.

Hill's textbook on *The Policy Process in the Modern State* provides a comprehensive analysis on the nature of policy formation in modern democratic states [Hill, 1997]. Hill's first two chapters describe the range of theoretical frameworks used to understand the state, including pluralism and its critique by Marxists. He then analyses the different models of the policy process in particular, and how

these different theories have influenced the way such an analysis is done. In framing this discussion Hill is clear that he is not making a case for the study of policy processes as being any different from any other social science research activity. He does point out that the nature of the policy process is that it is usually made up of a unique sequence of events, and that this means there is no opportunity to test earlier research by looking for the replication of a process. Therefore policy process studies are likely to be case studies using qualitative methods. In his conclusion he states that "policy analysis must be seen very much as an interpretive art" [Hill, 1997, p. 227], rather than having an expectation for validation of hypotheses.

Ozga discusses approaches to researching education policy. Her stated purpose is to "contribute to an argument in favour of the informed, independent contestation of policy by a research community of teachers and academics who have together developed capacities that allow them to speak with authority against misguided, mistaken and unjust education policy" [Ozga, 2000, p. 1]. Thus she sees this area, i.e. education policy, as "contested terrain" with no clear definitions allowing separation from other areas of social policy, and she sees that there is a struggle to define this policy, and influence it.

Ball has made many contributions to the debate on policy in education [Ball, 1990, 2008], with detailed analyses of the development of English education policy, as distinct from Welsh, Scottish and Northern Irish education policy. Ball provides an excellent exemplar of how to analyse the policy development process, over a medium term period, using a variety of research methodologies, including a detailed analysis of published policy documents, and interviews with people involved in the process. In at least some of this work Ball explicitly addresses his theoretical stance "I am certainly not a pluralist, at least I do not think I am; I may be a Weberian neo-plurist, to coin a phrase, but if I am I hold strongly to the tenet of 'dual polity'. That is to say, the role of representative institutions in social democratic politics is constrained and distorted by the various inequalities of power inherent in capitalism" [Ball, 1990, p. 2]. Ball has addressed the issue of policy texts in a range of places, perhaps most directly in "What is Policy?" [Ball, 1993] where he outlines his preference for the use of multiple theories, as well as multiple methods, when approaching such a complex area as policy. In this article there is detailed discussion of the importance of policy texts themselves, and of the dangers of regarding the texts as what policy itself is about.

So it is clear that there is an inherent danger in the method used in this thesis, that one may lose out on some important insights or be misled by an approach that focuses on the policy texts themselves. However, it is also true that policy texts are an important part of policy, and that flexible readings can yield useful understandings of policy.

5.3 Methodology and Method

The basic methodology used in this study is to analyse the formal written texts as a means of understanding the policy. It does not try to engage with the participants directly by interviewing policy makers, funding agency staff, or researchers. Thus the risk is that the analysis may miss some key insights that such an approach could have provided, but this is balanced by the openness and reproducibility of the analysis — all the sources are open to alternative readings by anyone else, and by the need for any academic analysis to maintain a clear focus. Further work is discussed in Section 8.4, and this addresses potential any narrowness of the approach pursued in this thesis.

5.3.1 Selection of Core Texts

In order to identify the core texts for study, a wide ranging survey was done of the available public policy texts. For the more recent period, since 2001, most texts were available in on-line repositories on the websites of the agencies who had sponsored them. For the earlier texts traditional library requests were made for physical copies. All of the texts were in the public domain and so did not require any negotiated access.

As outlined in Section 3.3, the interest in this area was motivated by a wish to understand the publicly stated reasons for the increase in publicly funded research in Ireland from the late 1990s onwards (c.f. Figure 3.1). Thus, the initial assumed time period of interest was 1990–2008. This was revised to be 1995–2008 when the core texts for analysis were selected as described here.

The initial list of potential texts was compiled by inclusively checking all of the agencies listed in Section 3.1 to see what publications each one provided, and whether any had potential relevance to SET policy in the period 1990–2008. This produced a large list of around two hundred potential texts. These texts were then provisionally analysed to see to what extent they did contain content that was relevant to SET or STI policy. This led to the identification of a subset of thirteen core texts that have been analysed in detail in Chapters 6 and 7. As part of this selection process the early boundary of 1995 was chosen. It was the publication of the first White Paper on Science, Technology & Innovation in 1996 [OST, 1996] that could be said to have begun a series of policy developments over the next 10–15 years, including the beginning of a Technology Foresight exercise, and the subsequent establishment of Science Foundation Ireland to fund research in the strategic areas identified by the foresight exercise. This White Paper extensively referenced the Tierney or STIAC Report that was published a year earlier [STIAC, 1995], and so the initial date for the analysis period was set at 1995 to include these documents.

The core documents can be seen to fall into two sets. The first set of core texts covers the period 1995–2000 and begin with a series of policy documents in the mid-1990s that led directly to dramatic changes to SET policy in Ireland. Other documents such as annual reports for the Higher Education Authority and annual reports from the newly established Enterprise Ireland were considered, but did not contain enough relevant text on SET policy to justify analysis. The results of this analysis is presented in Chapter 6.

The second set of core texts deals with the period from 2001–2008. This set includes the documents produced by new funding agencies established as part of the new policy framework (e.g. Science Foundation Ireland). It also includes existing agencies which were given a large allocation of research funding to distribute; this led to the creation of new funding instruments within these existing funding agencies (e.g. the creation of the Programme for Research in Third Level Institutions, PRTLI, within the existing Higher Education Authority, HEA). The results of this analysis is presented in Chapter 7.

The dividing date between these two sets of documents is not simply arbitrary. There is a definable shift in mode between these two periods. Essentially the first period is one of policy formation, and of various stakeholder's attempts to make a clear case for increased public investment in R&D in HEIs. In contrast, the second period is one of policy implementation, where the increased public investment in R&D has been provided, and the new funding streams are being allocated based on various systems, in some cases with new agencies being established. So arguably the types of author, and the types of audience for these policy documents both shifted between these two periods. Note that even though the initial evaluation of proposals for HEA PRTLI Cycles 1 & 2 (definitely part of the second phase) both predate the cut-off date, this does cause a problem as the key policy documents that the PRTLI programme itself produced happened after the cut-off date.

Readers unfamiliar with the agencies involved in Irish research funding policy and research funding awards are referred to the overview provided in Section 3.1 for a full list of these agencies, and some explanatory discussion. This context may be needed to make sense of the dense usage of acronyms in the list of key documents.

A summary of the core texts analysed is presented in Table 5.1.

Formation of a Policy: 1995–2000

- Policy Texts 1995–2000

    1. [STIAC, 1995] Science and Technology Division, Science, Technology and Innovation Advisory Council Report

Citation	Title
Formation of Policy 1995–2000: Policy Texts	
[STIAC, 1995]	Science and Technology Division, Science, Technology and Innovation Advisory Council Report
[DES, 1995]	Charting our Education Future: White Paper on Education
[HEA, 1995]	Report of the Steering Committee on the Future Development of Higher Education
[OST, 1996]	Science, Technology and Innovation White Paper
[CIRCA, 1996]	A Comparative International Assessment of the Organisation, Management and Funding of University Research in Ireland and Europe
Formation of Policy 1995–2000: Funding Reviews	
[Forfás, 1998a]	Basic Research Support In Ireland
Implementation of Policy 2001–2008: Policy Texts	
[Skilbeck, 2002]	The University Challenged
[ICSTI, 2002]	Measuring and Evaluating Research
[HEA, 2002]	Creating and Sustaining the Innovation Society
[Forfás, 2004]	Building Ireland's Knowledge Economy: The Irish Action Plan for Promoting Investment in R&D to 2010
[ESG, 2004]	Ahead of the Curve: Ireland's Place in the Global Economy
[OECD, 2004]	OECD Review of Higher Education in Ireland
[ASC, 2006]	Strategy for Science, Technology and Innovation 2006–2013
Implementation of Policy 2001–2008: Funding Reviews	
[Banda, 2004]	PRTLI Impact Assessment
[Brook, 2005]	SFI The First Years 2001–2005
[Indecon, 2008]	Value for Money Review of SFI

Table 5.1: Core Texts in Document Set

2. [DES, 1995] Charting our Education Future White Paper on Education
3. [HEA, 1995] Report of the Steering Committee on the Future Development of Higher Education
4. [OST, 1996] Science, Technology and Innovation White Paper
5. [CIRCA, 1996] A Comparative International Assessment of the Organisation, Management and Funding of University Research in Ireland and Europe

- Funding Programme Reviews 1995–2000

1. [Forfás, 1998a] Basic Research Support In Ireland

These texts mainly represent the view of the Department of Enterprise Trade & Employment (DETE) and the Department of Education and Science (DES), and to some extent, their agreement to a joint Science, Technology and Innovation (STI) White Paper [OST, 1996]. Arguably the main input from the DES, and its subsidiary, the Higher Education Authority (HEA), comes after the fact with the CIRCA Report [CIRCA, 1996], since the earlier education White Paper did not carry a large R&D focus [DES, 1995].

This thesis takes these sets of core texts as capturing the policy discussion, albeit with various emphases, that built a rationale for the importance of significantly increasing investment in R&D in Ireland, particularly in the higher education institutions.

Implementing a Policy: 2001–2008

This is the list of texts that have been formally analysed in Chapter 6 and Chapter 7.

- Policy Texts 2001–2008

1. [Skilbeck, 2002] The University Challenged
2. [ICSTI, 2002] Measuring and Evaluating Research
3. [HEA, 2002] Creating and Sustaining the Innovation Society
4. [Forfás, 2004] Building Ireland's Knowledge Economy: The Irish Action Plan for Promoting Investment in R&D to 2010
5. [ESG, 2004] Ahead of the Curve: Ireland's Place in the Global Economy
6. [OECD, 2004] OECD Review of Higher Education in Ireland
7. [ASC, 2006] Strategy for Science Technology and Innovation 2006–2013

- Funding Programme Reviews 2001–2008

    1. [Banda, 2004] PRTLI Impact Assessment
    2. [Brook, 2005] SFI The First Years 2001–2005
    3. [Indecon, 2008] Value for Money Review of SFI

These texts represent the public documentation produced during the period where it was clear that central government was prioritising R&D, and in particular supporting basic research in the higher education institutions. The HEA PRTLI first three cycles occurred in the late 1990s and early 2000s (Cycle 1 evaluations 1999, Cycle 2 evaluations 2000, Cycle 3 evaluations 2001). Science Foundation Ireland was initially set up in 2000 as a sub-board of Forfás, before it was established on a statutory basis in July 2003. Thus the groundwork was in place for the new funding to have some impact on R&D. At a very high level these reports reflect a shift from justifying the need for such funding as an investment, towards a discussion about how to prioritise its use.

Other Approaches to Selection of Texts

The closest to an existing list of suitable texts to include was found in the OECD Review 2004. A number of key texts were supplied by the HEA to the OECD committee responsible for the Review in 2004. A full list of these has been included in Appendix B. However, many of the texts were outside the scope of this thesis on research funding. This reference list dates up to 2004, so all of these texts were considered for potential analysis.

Of course further reference to these texts may appear in the thesis, as many have some interesting insights or relevance, although not included as a core text. In general the texts that were not analysed were considered to be beyond the scope of the analysis, in that they did not address research and development in HEIs, and how this should be funded.

The following texts were considered, and actually preliminarily analysed, but not included due to the prioritisation of texts that had more relevant information. Citations from these texts may appear throughout the thesis, but there is no dedicated analysis section in either Chapter 6 or Chapter 7.

- Policy Texts

    1. [Forfás, 1998b] Regional Innovation and Technology Transfer Strategy
    2. [DES, 2004] Ministerial Comment on OECD Review
    3. [Forfás, 2005] OECD Graduation benchmarks 2003
    4. [OECD, 2006] Country Report: Ireland

5. [HEA, 2007] National Infrastructure Review

- Annual Reports

  1. Enterprise Ireland Annual Reports
  2. HEA Annual Reports
  3. SFI Annual Reports
  4. SFI Internal Review Reports
  5. SFI Sustaining Progress Reports

- Funding Programme Reviews/Summaries

  1. [SFI, 2003] Achievements Report
  2. [HEA, 2006] PRTLI Directory (In 3 Volumes)
  3. [HEA, 2007] HEA/Forfás Research Infrastructure in Ireland — Building for Tomorrow

  Note that two key funding reviews of the SFI and HEA were included [Banda, 2004; Brook, 2005; Indecon, 2008]. Other reviews, and summaries of achievements, were excluded due to the lack of any serious discussion of research and innovation models. The achievements reports were a positive publicity relations exercise focusing on key success stories, rather than a critical evaluation. The HEA research infrastructures report was a serious review, but focused on buildings and expensive capital equipment, and was not focused on the outputs of the research programmes themselves, and so was considered unsuitable for inclusion in this analysis.

In general it was harder to analyse texts that did not have a higher level policy formation goal using the framework developed, as there were many potential reasons in such texts for not referring explicitly to any model of research or innovation informing the text. In particular it was harder to deduce any problem due to exclusion of such information. Thus if an annual report of Enterprise Ireland (EI) did not discuss particular models of research or innovation, one could not draw many conclusions from the omission. If however, they published a report on the future of Ireland's Innovation Society, for example, at least such discussion of such models would be a requirement to justify any investment being requested. So the texts that were analysed and not included had mainly negative responses to any identification of explicit or implicit models of contextualisation of R&D, and had little justification for a conclusion to be drawn from this omission.

5.3.2 Structured Reading Framework for Core Texts

In order to ensure that the structured reading of the core texts is consistent a simple set of questions was drawn up, and these questions were asked of each text, and evidence sought to answer each question.

This was too complex to automate with automatic word counts. In addition some of the documents were only available in printed hard copy and so not directly amenable to automated analysis.

The questions asked of each text are designed to elicit evidence to help answer the core research question:

> *"Is there evidence in the development of Irish research funding policy for a contextualisation of science, engineering and technology?"*

The terminology relating to this question was discussed in Chapter 2, where the question itself was formulated. The pragmatic context in terms of the agencies involved in Ireland was summarised and discussed in Chapter 3. The academic theoretical context, where formal taxonomies of research and innovation were defined, and where theories of how research and innovation operates, was discussed in Chapter 4. From this it should be clear that the key emphasis for the search for this contextualisation of Irish research funding policy lies not in the pragmatic issues of how many jobs are created in funded research centres, and how many students graduate with research degrees, though these do have a direct contextual impact outside the research centre on the regional economy (supplying direct jobs, and supplying a trained workforce for other employers). Rather the question is whether the research should be linked to the demands from outside the research community itself, whether industry links, and a choice of research direction based upon industry feedback, is important. Thus the reading framework tries to identify such issues as cleanly as possible in potentially lengthy texts.

The following represents a structured reading framework for the core texts:

1. *Does the text directly cite any external theory of research or of innovation (in references, bibliography or footnotes)?* The aim here is to identify a model with which the text aligns itself, and to discuss whether that model views academic research as conducted outside of any contextual requirements from industry or society, validating itself within a pure academic context, or requires societal/industrial contextual links for the research activity to have validity.

2. *Does the text use terminology that is an implicit citation of an external theory of research or innovation (this could mention the name of an author, or the name of a theory, or use the terms 'basic research' and 'applied research' in a way that assumes a linear relationship, without providing a*

citation? So again the key underlying purpose is to ascertain whether the text itself aligns itself with a model that views academic research as conducted within a pure academic context, outside of any external contextual requirements from industry or society, or requires such external contextual links—the difference between this and the previous question is that there is more room for error in the analysis, as it is potentially more subjective to deduce a model that informs a text, when it is not actually being cited by the text.

The analysis of each text includes five subsections:

1. *Summary of Document* An overview of the document in its own terms, not necessarily with a primary focus on Irish R&D funding for SET;

2. *Summary of Document Significance* A statement of the main importance of the document; this is particularly necessary for readability when this importance lies outside of the core scope of Irish R&D funding for SET;

3. *Analysis: Evidence of Explicit Contextualisation* An examination of the explicit evidence for models of research and innovation.

4. *Analysis: Evidence of Implicit Contextualisation* An examination of the implicit evidence for models of research and innovation.

5. *Analysis: Summary* Where the analysis above is long and complex, the summary serves to highlight the key issues identified. Where the analysis is shorter, the summary synthesizes the points already made, the advantage of having a separate subsection being the ease of skim reading the whole of Chapters 6 and 7.

To defend this analysis from potential criticism that it is overly subjective, an analysis style that includes long quotations from the main texts being analysed is used. This serves to allow the reader to see the evidence, especially for arguments about implicit models of research and innovation, in enough of each document's own linguistic context to make a sensible judgement as to whether the deduction and analysis are justified. The risk of this approach is that it makes the analysis slightly less elegant and more cumbersome, but it does serve this defined purpose. It could still be argued that the analysis is selective, and hence subjective, in highlighting only those sections of the text that confirm the central thesis. In response to this is that, in fact, the findings are not what had been originally anticipated, as will be explored in the final discussion in Chapter 8.

In terms of an understanding of what contextualisation means, these questions where borne in mind when analysing both the explicit and implicit reference to models of research and innovation:

1. Does the text discuss any of these contextual factors for research:
   (a) links from research to industry/commerce?
   (b) links from research to government (international, national, regional or local)?
   (c) usefulness of research to any external (to the researchers) constituency?
2. Is there any evidence of a divergence of theory from practice, with respect to contextualisation, in the text?

5.4 Summary

This chapter has outlined the key elements in the method for the analysis of texts, the selection of the texts, and the structured reading guide to these texts. The framework for the analysis is defined as a search for evidence of increasing contextualisation of SET policy, using an analysis based on the explicit and implicit reference in the documents to four models of research and innovation, three of which deal with non-linear models that assume increasing contextualisation in various ways (i.e. relevance of research to society and to industry).

Therefore the framework has been established in this chapter and the preceding chapters, and the subsequent chapters for the work which now follow and which is detailed in Chapter 6 and Chapter 7. Finally Chapter 8 provides a synthesis of the arguments and the results as well as offering concluding observations.

Chapter 6

Analysis of Texts: 1995–2000

6.1 Introduction

This chapter analyses a series of texts from the period 1995 to 2000, texts that lay the policy framework for the increased investment by the Irish government in research, and particularly Science, Engineering and Technology research, in Ireland.

Many of the documents analysed are not primarily about models for research and innovation, so in some senses it is unfair to expect them to yield to this type of analysis. However, it is a feature of the overall research funding policy that it is linked, either directly or indirectly, to the concept of the potential future economic welfare of the country. Consequently many of the documents provide some evidence that can be examined. To help do justice to all the documents discussed, the analysis below includes a brief summary of the document, and a discussion of its significance in its own terms, before going on to discuss the direct and indirect reference to these models.

This chapter analyses a number of documents that came out in the latter half of the 1990s. The subsequent chapter, Chapter 7 analyses documents published between 2001 and 2008. Previous chapters have established the context for this analysis. The final chapter presents a synthesis of the key findings and the conclusion.

6.2 Policy Formation Texts

6.2.1 STIAC 1995: Science, Technology and Innovation Advisory Council Report

Summary of Document

STIAC (Science Technology and Innovation Advisory Council) was established in 1994, and this report subtitled *Making Knowledge Work for Us*, published in three volumes, was produced to argue the case for a new evaluation of how research should be funded in Ireland, both in terms of the industrial investment in research and in terms of the national government's investment in research in higher education institutions. STIAC was chaired by Dan Tierney, and this report is often cited as the Tierney Report [STIAC, 1995]. Volume One is the main report. Volume Two comprises materials prepared by consultants (i.e. a CIRCA Group Europe report of 54 pages plus appendices, and a Technoplis report of 20 pages). Volume Three is made up of fourteen appendices, including working versions of chapters of the main report. In sum this is one of the most comprehensive and professional reports ever produced on Science Technology and Innovation in Ireland, and considered over 150 submissions from interested parties.

The report was publicly launched on 27th March 1995 when the Minister for Enterprise was Pat Rabbitte of the Labour party, which was in coalition with Fianna Gael and Democratic Left, forming the so-called Rainbow Coalition. Following its publication the government created a Task Force, chaired by John Travers, Chief Executive of Forfás, and made up of representatives from relevant government departments, to examine the recommendations of the STIAC Report and report to the Cabinet Committee.

In the Executive Summary Travers highlighted the following as the key recommendations within the STIAC report:

> "The Report goes on to make a series of detailed and practical recommendations through which these principles can be translated into action. Among the most important are:
>
> - The objective to double the level of R & D undertaken by the Business Sector with State support by 1999.
> - The objective to increase funding for basic research from £1.5 m to £6 m. per year, the proposal to provide a special fund for research equipment in the Third Level sector and the call for a Research Charter to promote greater interaction between the research capability of the Universities and other Third Level Bodies and the Business Sector.

- The proposals to establish new management structures for the Programmes in Advanced Technology (PATs) which will clarify their objectives and provide the means by which priorities can be established including those relating to the needs of the indigenous sector of Irish industry.
- The proposals to establish a National Task Force to achieve a "state of the art" Communications Network.
- The objective to create a Special Awareness Fund of £1m per year to improve the awareness and understanding of the value of science, technology and innovation to the achievement of national social and economic objectives.
- The proposals to put in place new organisational arrangements to reflect the importance of Science, Technology and Innovation to our development policies including a Cabinet Committee on Science & Technology, the establishment of a National Office of Science & Technology and the preparation and prioritisation of an Annual S & T Plan."

[STIAC, 1995, Executive Summary]

At the time the report sparked discussion, as is captured by Mulcahy's paper [Mulcahy, 1996] summarising a debate hosted in November 1995 in the University of Limerick on the topic of "Challenges for Partnership between University and Industry: a Response to the Tierney Report on Science, Technology and Innovation". The organisers were conscious that the publication of STIAC provided "an opportunity for those who are concerned about Science, Technology and Innovation (STI) policy in Ireland" to contribute to the debate in advance of a White Paper being published [Mulcahy, 1996, p. 50]. It should be noted that Mulcahy was a member of STIAC and so was very familiar with the report.

Summary of Document Significance

The report could be considered the starting point for the complete transformation of Irish funding for higher education institutions. It argued forcefully, and with strong academic credentials, the case for national policy prioritisation of research and development both in terms of industrial R&D and in terms of academic research. It had a strong theme of the need for an integrated policy for STI summarised in the following recommendation:

> "There are 41 Agencies and institutions engaged in S&T activities within the public sector. Opportunities for interinstitutional collaboration, synergy, rationalisation or greater mobility of personnel

> should be investigated. Arrangements should be put in hand to ensure that institutions participate in national and international networks through which new knowledge is acquired and shared. The Inter-Departmental Committee should provide a lead in this regard."
> [STIAC, 1995, Chapter 8]

The report led directly to the setting up of a task force, led by John Travers of Forfás, to publish a White Paper on how to proceed based on STIAC.

Analysis: Evidence of Explicit Contextualisation

The STIAC Report directly refers to the idea of a *National System of Innovation*, stating that Ireland does not as yet have one.

> "Innovation is a complex process and the concept of a
>
> *'national system of innovation'*
>
> (NSI) has been developed internationally to identify the key factors influencing innovation."
> [STIAC, 1995, Chapter 2]

Volume One of the report contains a detailed set of references including the following academic paper: Mansfield [1992].

The CIRCA Report in Volume Two (not be to be confused with [CIRCA, 1996]) contains 118 references in which Freeman, Nelson, and Edquist are all explicitly cited with reference to National Systems of Innovation. This report also cites Porter on more than one occasion.

Analysis: Evidence of Implicit Contextualisation

The report is written from an economic perspective, with many references to the link between investment in research and development, and the potential economic benefit in innovation.

> "Despite the apparently healthy picture painted by the official macroeconomic statistics, there are serious grounds for concern about the real state of indigenous enterprise.
>
> These concerns are reinforced by a significant number of studies and reports relating to economic development, particularly industrial development. There is an increasing consensus that a poor record in innovation is at the root of the problem.
>
> There is a link between science, technology and industrial innovation."
> [STIAC, 1995, Chapter 2]

> "Government must recognise and promote a long term investment strategy to build up the elements of NSI. Fundamental to this is the need for an integrated national STI policy.
>
> The component parts of the innovation system need to be examined in depth to identify the important weaknesses. On the demand side is the enterprise sector, while the supply side is represented by the Third Level and State sectors. Linkages with these sectors and with the rest of the economy are also critical.
>
> Expenditures on research and development in Ireland is low compared to most other OECD countries. Business sector R&D is an important element of the innovation system and needs to be substantially increased. Funding for basic research is inadequate and the Government must increase its level.
>
> The traditional low status of science and technology in this country means that the political mechanisms and structures do not exist to co-ordinate and prioritise the State's annual investment in S&T activities."
> [STIAC, 1995, Chapter 2]

In Volume One there is a list of definitions including: R&D, pure basic research, oriented basic research, applied research and experimental development with the definitions provided coming from the OECD Frascati Manual.

The STIAC report is comprehensive in its nature and covers more than one angle on most issues, whilst maintaining a strong theme that Ireland currently lacks a coherent integrated Science Technology and Innovation policy linking all the key players, and arguing for the creation of space for basic and oriented basic research funding in higher education.

Analysis: Summary

The Tierney Report, or STIAC Report, is the core document justifying the economic view of investment in R&D that led to investment over the next ten years and beyond. It explicitly follows the National Systems of Innovation model of research and development, arguing for investment in all elements that make up that system.

6.2.2 DES 1995: Charting our Education Future — White Paper on Education

Summary of Document

This White Paper, and the earlier Green Paper in 1992 (Education for a Changing World), was not focused on the higher education sector, but on all levels of formal education. However research and development is mentioned and there is a section on HEIs and the binary system.

> "This chapter has already referred to the different missions of universities and technological colleges. Universities are mainly concerned with undergraduate and postgraduate degree level programmes, together with basic and applied research. Technological colleges (with special considerations applying to the Dublin Institute of Technology) focus mainly on certificate and diploma programmes, with a smaller number of degree programmes and a growing involvement in regionally orientated applied research.
>
> The role of universities as discoverers and disseminators of knowledge sets the context within which links emerge between research and teaching. The value of research also reaches into the spheres of technological development and international competitiveness: the higher education sector is a major supplier to research efforts in Ireland. In the ten-year period, 1982 to 1992, expenditure on research in the higher education sector increased in real terms by 200 per cent.
>
> The Report on the National Education Convention stated that 'there would be a general welcome for the development of a more explicit national policy on the funding of research in third level education' (p. 97). In relation to the block grant to colleges, the Report stated that "the unified budget which forms the block grant to colleges would provide the basic level of research funding. It is accepted that selectivity would arise in relation to additional funding for which academics would be encouraged to bid" (p. 97).
>
> In moving to a more explicit policy in relation to research, the Department will take into account the consultancy study in relation to university research and its funding, which is being carried out under the aegis of the Higher Education Authority, as well as the relevant recommendations made by the Science Technology and Innovation Advisory Council.
>
> A number of important principles will inform a research policy for the third-level sector:

- the unified teaching and research budget, which forms the block grant to colleges, will be continued; it will provide the basic level of research funding
- the role of research in course development and the advancement of knowledge in all disciplines will be recognised
- any additional funding for research will be provided as a separate budget, for which competitive bidding will be the norm with independent assessment by international peers on research proposals
- within the education sector, most basic and strategic research will be predominantly in the universities while the focus of the technological colleges will be on applied regionally orientated research
- the role of research in technological development and international competitiveness will be recognised
- the need to develop centres of excellence involving co-operation between institutions and disciplines, particularly in expensive research areas, will be examined."

[DES, 1995, pp. 106–107]

Summary of Document Significance

Perhaps the key outcome from this White Paper in terms of research policy was the encouragement of the development of institutional research strategies, later made a requirement for HEA PRTLI funding submissions, that were made as institutional submissions. This has encouraged the development of a strategic approach institutionally to developing research.

> "Within this framework, each institution will develop and publish an explicit policy on its approach to research, including the broad balance between research and teaching commitments within disciplines. The policy will also set out the key aims of research activity and the principal criteria for evaluating the effectiveness of research within the institutions."
> [DES, 1995, p. 107]

Its real significance for higher education as a whole lay elsewhere; it established the ground rules for the new Universities Act of 1997.

Analysis: Evidence of Explicit Contextualisation

Not having an innovation focus there is no explicit reference to models of innovation of research.

In the small section on links to industry for higher education there is no explicit reference to a model of innovation.

None of the key theoretical texts is mentioned in the principal references, that instead largely cross-reference other relevant government reports.

Analysis: Evidence of Implicit Contextualisation

This document written within the Department of Education in 1995, does, however, contain a mention of the potential external links for universities and other HEIs:

> "The knowledge and skills of people, coupled with the quality of research and development, have a critical contribution to make to economic competitiveness, prosperity and social cohesion. Higher education institutions have an important leadership role in providing and continually renewing the skills and knowledge-base which are vital to our future progress.
>
> Interaction between higher education institutions and the economy carries considerable benefits for all those involved. This interaction provides significant opportunities for staff to benefit professionally and for students to profit from the staff's experience. It also allows colleges to use their expertise for the benefit of society and the economy. In addition, it opens up new funding sources for the institutions and promotes mutual understanding between business and higher education.
>
> A strong pattern of co-operation has already been established, in research and development and, to a lesser extent, in management and in technical training and retraining. In this respect, the role of the Regional Technical Colleges and the Dublin Institute of Technology has been recognised in the relevant legislation.
>
> There is potential for expanding research and development and for establishing a pattern of support for recurrent technical and management training, through collaboration with the different sectors of the economy. Institutions will be encouraged to expand their activities through an explicit and positive policy on interaction with the economy. Such a policy would provide for:
>
> - research and development and the diffusion of scientific knowledge and technological and managerial innovations

- opportunities for renewal and life-long learning for professional, managerial and technical staff in all sectors of society and the economy
- the putting in place of arrangements for co-operation with business, building on existing best practice, nationally and internationally.

There will be a particular emphasis on collaboration with the indigenous sector of the economy, to promote the highest levels of technological and managerial capacity and in order to encourage Irish firms to employ scientific and technical personnel.

The Higher Education Authority will be responsible for monitoring the policies of the colleges and for providing appropriate support at national level."
[DES, 1995, pp.96–97, highlighted as in original text]

This quotation shows evidence of an awareness of the changing context brought about by an emphasis on R&D. Thus the HEIs' role as creating knowledge and developing skills in people that then become part of the workforce is balanced by their role in directly contributing to the economy via R&D which is in turn potentially linked to the commercialisation of that new knowledge. The report encourages an increasing partnership role with industry, including indigenous industry, for HEIs. This could be viewed as an indirect support of a National Systems of Innovation view or of a Triple Helix view that emphasises the creation and development of those complex links as the basis of an innovation ecosystem.

Analysis: Summary

The document is aware of the contextualised role for higher educational institutions, but this role is not framed within a theoretical framework of a model for knowledge production. Some of the language used suggests an awareness of the increasing partnership role with industry in terms that could support a National Systems of Innovation view or a Triple Helix view.

6.2.3 HEA 1995: Report of the Steering Committee on the Future Development of Higher Education

Summary of Document

This report was prepared largely in parallel with the STIAC report and the White Paper on Education, and published a few months afterwards in June 1995 (though its original terms of reference envisaged a June 1994 publication). The

report was prepared by a steering committee chaired by Noel Lindsay (HEA), and a Technical Working Group led by Professor Jerry Sexton (ESRI).

The subtitle of the report *Based on a Study of Needs to the Year 2015* indicates the main focus, i.e. how the HE sector should respond to the changing needs for student education. The first item in the terms of reference, 1(a), includes four sub points:

> "1(a) to prepare projections to the year 2015 of the total potential enrolments in higher education by reference to trends and polices in:
>
> - participation levels in senior cycle education;
> - transfer rates of school leavers to higher education;
> - participation levels of mature and second-chance students;
> - improved participation of the socially and economically disadvantaged."
>
> [HEA, 1995, p. 92]

Thus the report's driving focus is on student numbers, and the main tables deal with current student numbers and projections of future student numbers, or in the report's own words the scope is limited to the "quantitative expansion of the system" [HEA, 1995, p. 90].

Therefore it may not be surprising that although there are twelve chapters, none is dedicated to research. The closest is Chapter 6 *The Role of Higher Education in Economic Development*. The report acknowledges that this is outside its scope, stating in its conclusions:

> "The pressure for places and expansion in student numbers brings with them concerns that the important and indeed critical work of higher education in research and development may not receive the attention it needs, particularly as so much of the funding is closely linked to student numbers. We have stressed the importance of this work in support of industry and to neglect it would be at severe cost to national economic development."
> [HEA, 1995, p. 89]

The reference here is to the block grant for universities, based on student numbers, that is used for teaching and research.

Summary of Document Significance

This document was important in providing justification for the allocation of resources to certain institutions for certain purposes, based on the existing and

projected numbers provided. For example it comments on the newly established institution in Tipperary, the TRBDI (Tipperary Rural and Business Development Institute), now called the Tipperary Institute, and suggested that it could not justify upgrading it to full RTC status, but that it may develop to such a point where this might be justified.

Analysis: Evidence of Explicit Contextualisation

There is no explicit reference to any model of research or innovation. The report does explicitly cross-reference the STIAC report in Chapter 6.

Analysis: Evidence of Implicit Contextualisation

The placing of all discussion of research into Chapter 6 entitled *The Role of Higher Education in Economic Development* in itself implies an economic perspective on the value of research. This short chapter (barely over 4 pages) discusses the interaction between HE and industry, and the funding scheme known as the PATs (Programmes for Advanced Technology), administered originally by Eolas and then Forbairt that became Enterprise Ireland.

Analysis: Summary

The scope of this document means there there is little direct or indirect reference to any model of research and innovation.

There is a strong implication that the courses offered by the HE sector should be tailored to meet the skills needs of Irish industry.

6.2.4 OST 1996: Science, Technology and Innovation White Paper

Summary of Document

The Science, Technology and Innovation White Paper of 1996 [OST, 1996] is effectively the official government response to the STIAC Report [STIAC, 1995]. Nearly every section concludes with a summary of what Tierney and his colleagues articulated in the STIAC report.

The introduction to this White paper on STI is written by Pat Rabbitte, Minister of State for Commerce, Science and Technology.

The work of the White Paper derives from the Task Force set up to review the STIAC report, and this Task Force's terms of reference are given as an appendix.

Summary of Document Significance

The significance of the White Paper is that it led directly to the implementation of many of the STIAC report's original recommendations. The key conclusions of STIAC are re-iterated:

> "Among the key conclusions of the TIERNEY Report are that:
>
> - there is a low level of research and development in Ireland, particularly in the business sector. Furthermore, the economy generally buys in the innovations of others in order to upgrade technologically, e.g. through technology acquisition;
> - there is a need to provide increased resources for those involved in "knowledge generation", particularly the third-level colleges, and to improve the interaction and knowledge transfer between the third-level sector and enterprises;
> - there is a need to increase the level of understanding of the contribution of science and technology to innovation by business people and policymakers;
> - the ultimate objective of the national science and technology effort is to achieve a much higher level of innovation performance in industry and other sectors. This requires the co-ordination of both the private and public sectors; to that end, the Report proposes changes in policies and programmes in the areas of business, the third-level colleges and the public sector."

[OST, 1996, p. 50]

The White Paper is keen to track progress of implementation to date:

> "Since the publication of TIERNEY, and in the light of the ongoing work of the Cabinet Committee and Task Force, the Government has already taken action on a number of specific recommendations as described below:
>
> - taxation — the 1995 and 1996 Finance Acts provide for a 400% deduction for incremental R&D expenditure; also in 1995 the Business Expansion Scheme was extended to shares in companies providing R&D services to other companies;
> - basic research expenditure was increased from £1 million to £1.5 million in 1995 and to £2 million in 1996;
> - strategic research funding was increased in 1995 and again in 1996;

- funding was increased for college/industry applied research;
- the National Research Support Fund Board was established as an independent body to administer an open and transparent scheme to support third-level basic and strategic research;
- increased funding was provided for technology brokerage in 1996;
- increased funding was provided for the 'Techstart' Scheme to place graduates in firms;
- the annual PhD support grant has been doubled to £2,000 per annum;
- funding has been provided in 1996 for a new post-doctoral fellowship scheme;
- additional funding was provided to expand the company technology audit scheme to include design and product development capability;
- funding was provided for a programme, to be piloted in 1996, to encourage inter-firm collaborative networks;
- increased funding was provided for regional technology service centres in 1996;
- funding has been provided for a new international research collaboration scheme;
- an STI Awareness Programme was initiated in 1996;
- an R&D Management Development Scheme, to provide training in R&D and innovation management for companies, was launched in 1996."

[OST, 1996, p. 56]

The White Paper is also keen to promise further action, as indicated by the outputs from the Task Force on the STIAC report:

"Decisions of the Government

- The Government will develop an integrated procedure for the prioritisation of S&T spending, based on the Forfás annual Science Budget and draft spending plans of Departments. The process will form an integral part of the annual Estimates and Budget cycle.

- The process will be conducted by an Inter-Departmental Committee under the direction of a Cabinet Committee. The Minister for Commerce, Science and Technology will establish terms of reference and modus operandi of the inter-Departmental Committee.
- Forfás will make proposals on the function, scope and optimum process for a technology foresight or alternative process for generating future technoeconomic scenarios as an input to the prioritisation process.
- Each Department will designate an Assistant Secretary (or equivalent rank) with responsibility for promoting and co-ordinating its science and technology policy and budgets.
- The Office of Science and Technology (OST) will have responsibility for national co-ordination of STI policy which function will remain as part of the Department of Enterprise and Employment.
- A permanent STI Advisory Council, representative of wide-ranging interests, will be established.
- Funding for science and technology, on a programme basis, will increase in line with priorities, when proven and as resources permit.
- The Government will commission a study of the implications for science and technology funding and alternative sources, post-1999 Structural Funds."

[OST, 1996, p. 61]

Note that Forbairt was later renamed Enterprise Ireland. This set of actions included a commitment to establish a technology foresight exercise that was in turn to lead to the establishment of Science Foundation Ireland to manage the funding in the strategic research areas recommended by the foresight exercise.

The STIAC report and this White Paper created the foundation for the future development of STI policy in Ireland.

Analysis: Evidence of Explicit Contextualisation

One of the key chapters in this report, *Chapter 3: The System of Innovation in a National and International Context*, emphasises National Systems of Innovation, taking its influence from the STIAC report [STIAC, 1995] and from two cited NESC (National Economic and Social Council) reports: Report 93 [Mjoset, 1993] and Report 96 [NESC, 1993].

"The 'Innovation System' Approach

In looking at Ireland, the Report draws on the concept of a 'National System of Innovation'. This was defined as 'the collection of all institutions and mechanisms (public and private) that interact to stimulate and support innovations in products and systems in the national economy'.

The National System of Innovation (NSI) model also encompasses broad cultural and attitudinal themes, for example the environment for research and technological development in Ireland; aspects of the education system (appreciation of science and technology at primary/second level; funding and application of research at third-level); the perception of science and technology among the general public, the business sector and policy makers in the public and private sectors. Finally, the model extends to interactions and feedbacks between the NSI in the narrow sense and other aspects of public policy and national institutions: private sector financing of innovation; tax treatment of research and development; and the role of the State in funding and supporting a balanced portfolio of programmes for research and technological development.

Developed in the Nordic countries, this model has been highlighted in previous National Economic and Social Council (NESC) reports. It has been persuasively argued that it throws significant light on why Ireland's development performance is so poor vis a vis relevant peer countries and economies and, indeed, the wider world.

The analysis based on applying the model of a National System of Innovation to Ireland attributes poor relative development performance to the presence, over a long period, of a series of interlocking, inter-related and cumulative vicious circles. In essence we have a weak National System of Innovation."
[OST, 1996, p.50]

In Chapter 3 the report explicitly discusses controversies around the role of basic research with respect to an economic role, citing Vannevar Bush:

"No subject in the history of public policy debate has generated more heat and less light than the controversy over the role and significance of basic research in the innovation system. Things were a lot clearer in the seventeenth century when Francis Bacon argued that theoretical science is the only real science, the basis of all knowledge and advance, and that such work must be funded by the State as private sources would have neither sufficient resources nor interest. By

> the late twentieth century, however, the complexities of history had considerably muddied the waters.
>
> The basic research system is not confined by state boundaries. Nor is it the property of any one state. Basic research is like literature. It is carried out in a global context, with researchers from all over the world deriving inspiration and ideas from each other and competing for the next Nobel prize. The university system is responsible for almost all of the basic research carried out in Ireland; however, it represents only one third of the total research carried out in colleges. Over the past decade, college research activity has become more oriented towards applied and developmental research as academic researchers generate funding through external contracts.
>
> But does basic research lead directly to economic benefit for the State in which it is carried out? Wealth comes from the application of science. The post-war performance of Japan owed nothing to its own performance of basic research and everything to its ability to find out, understand and appropriate what other countries had discovered through their own research efforts. In particular, Japan targeted the United States, by then the world leader in state-funded basic science as a result of the most influential of all science policy documents: Science - the Endless Frontier, by Vannevar Bush, Chief Scientific Advisor to the US Government at that time. Others have argued that the continued strength of the US economy over the last fifty years is a reflection of its leadership in basic science and of the strength of its universities and research infrastructures."
> [OST, 1996, pp. 32–33]

Thus the report acknowledges the complexities of the debate and focuses on the NSI model as a clear paradigm for developing a new STI policy in Ireland. The debate thus becomes about how to create a critical mass across a range of types of activity, and then allow the interrelationships to work. The report is very concrete about some specific funding measures to specific types of organisation to make this happen, i.e. universities, institutes of technology, multinational companies and SMEs. It is also specific about the central management structures within government, and the collaboration between departments required to realise its vision of an integrated STI policy.

Therefore this report provides strong evidence of a contextualisation of research into an economic context at the policy level.

Analysis: Evidence of Implicit Contextualisation

The argument is made in the report that investment in basic research is important, as it is a key part of the National System of Innovation, and that this investment is vital for the economic future of the nation. However little evidence is provided of the mechanisms by which this economic return actually materialises. It could be argued that therefore this argument is in fact an implicit linear model assuming that innovation derives from basic research. However the report does also contain explicit discussions of the complexity of innovation and how it is not simply about commercialising invention. Thus perhaps the best conclusion is that the report fully and explicitly endorses the NSI approach.

Analysis: Summary

This document very explicitly discusses the underlying rationale for justifying expenditure on research in economic terms. It addresses the debates that have occurred, and acknowledges the potential for disagreement. Despite this higher level view, it takes a very clear economically driven philosophical position, linked explicitly to the NSI model, citing this model and its key authors.

6.2.5 CIRCA 1996: A Comparative International Assessment of the Organisation, Management and Funding of University Research in Ireland and Europe

Summary of Document

Not to be outdone by the Department of Enterprise, the Higher Education Authority (who at the time managed the universities for the Department of Education—as of 2007 they also manage the institutes of technology) commissioned a report from the CIRCA Group Europe to carry out a comparative assessment of the organisation, management and funding of university research in Ireland and Europe [CIRCA, 1996].

Published in December 1996 it could be argued that it attempted to bring the same level of academic and intellectual rigour to the education side of the debate about research and innovation as the STIAC report [STIAC, 1995] had to the enterprise side of the debate. Pragmatically it was also clear that government funding in this area was going to be increased, as promised in the White Paper on STI [OST, 1996] published two months earlier, and also sign-posted by the reaction to the STIAC report over a year earlier [STIAC, 1995]. This report could be seen as the HEA arguing that a significant share of this upcoming funding be allocated to research activity within Irish university system (and limiting the role

for the RTC sector).

As it was commissioned by the HEA rather than directly by the Department of Education, no government minister is directly associated with this report. It was published in December 1996, when Niamh Bhreathnach (Labour) was Minister for Education as part of the Rainbow Coalition that lasted until the following year.

Summary of Document Significance

This report was published after the STIAC report and the While Paper on Science Technology and Innovation, that were largely driven by the Department of Enterprise. It is clearly a response to the new environment signalled by these developments, arguing the case for investment in university-led basic research programmes, and acknowledging that there could be no direct promise of economic return for this investment, but that it was clear that this type of investment was necessary for any modern, growing economy.

Although the report did not come directly from the Department of Education, but instead was commissioned directly by the Higher Education Authority, it nonetheless effectively represents the education side of the debate on research and development setting out their stall in the national debate. Thus this report became part of the justification for further increases in investment in research in Ireland.

To be fair to the argument that had been made by STIAC and the White Paper on Science Technology and Innovation, they also argued the case strongly for investment in research in the higher education institutions, so it is not the case that the HEA needed CIRCA to redress an imbalance in the policy. Rather it was an engagement with what was effectively becoming a national consensus on the importance of STI.

Analysis: Evidence of Explicit Contextualisation

A detailed bibliography is provided for Chapter 2, *Some Recent International Policy Trends and Views in Relation to the Organisation and Management of University Research* and Chapter 4 *University Research in Ireland — Its Funding, Outputs and Quality.* Other substantive chapters do not have explicit citation i.e. Chapter 3, *Organisation and Management Practices of a Cross Section of European Universities — The European Context*, Chapter 5, *The Irish University Sector*, and Chapter 7, *Findings and Conclusions.*

As can be seen from the titles of the chapters, and of the report, the emphasis is not on theoretical models of research and innovation, but on how the institutes manage research, and how it is funded. However, this does of necessity raise

interesting issues about definitions and models. In terms of explicitly addressing valid models of research and innovation, Chapter 2 is the most relevant. In Chapter 2 the report discusses the impact of university R&D, citing authors whose approaches could be generally categorised as a resistance to the commercial pressures on academic research agendas. These quotations are my selections to give an indication of the author's viewpoints.

Feller argues the dangers to the overall heath of academic research that can result when even only a subset of leading US universities pursue commercialisation opportunities.

> "'Thinking one can' may be a sign of creative and financially astute entrepreneurship on the part of universities. But whether profitable or not, these ventures serve to shift academic researchers from the social roles in which they are most efficient, as suppliers of a collective good-scientific and technological knowledge."
> [Feller, 1990, p. 347]

Pavitt argues for keeping basic research funding separated from commercial concerns, justifiable as a 'public good':

> "Our analysis suggests that the justification for public subsidy, in terms of complete inappropriability of immediately applicable knowledge, is a weak one."
> [Pavitt, 1991, p. 117]

In addition the literature review in chapter 2 looks for citations to support the view that basic research can provide an economic benefit but acknowledges that "Economists have generally not been successful in attempting to measure return on investment in basic research" [CIRCA, 1996, p. 26]. CIRCA cites Abramovitz:

> "the advance of knowledge lies at the core of modern growth processes and is more than an inference from growth accounts. It is a perception enforced by well over a century of common experience."
> [Abramovitz, 1989] cited in [CIRCA, 1996, p. 26]

Picking up the strong theme in STIAC [STIAC, 1995] the report references National Systems of Innovation briefly, arguing that that model warns of "the dangers of not maintaining a balanced capability in all components of the system" [CIRCA, 1996, p. 27].

Analysis: Evidence of Implicit Contextualisation

Throughout many of the sections of the report reference is frequently made to "basic research" and to "applied research" implying an acceptance of general

Frascati terminology. The report is a clear argument at national policy level for basic research funding to be increased, and for that funding to target the Irish universities.

Analysis: Summary

The emphasis of the report is not on models of research and innovation, but on how institutes manage research activity.

The cited references support a model that argues for investment in basic research as a public good, rather than directly for an economic benefit. The general tone of the document is to justify a clear separation of pure academic concerns in basic research, from commercially-linked concerns in applied research, and an argument that the former should be adequately funded as a public good.

Thus the indirect linear model is being supported, with an agreement that the link onwards from basic research to commercial exploitation should not be used as a primary metric for the success of basic research funding.

6.3 Additional Texts—Funding Programme Reviews

6.3.1 Forfás 1998: Basic Research Support In Ireland

Summary of Document

This document [Forfás, 1998a] reviews the operation of a funding scheme that pre-dates the main thrust of the analysis in this thesis, the Basic Research Grant (BRG) scheme operated by Forbairt (the precursor to Enterprise Ireland). The review covers the period 1989–1996, and involved extensive research including:

1. Exploratory interviews with scientists and policymakers to improve qualitative understanding at the outset;
2. A literature review to capture what the innovation and science policy literature has to say about the relationship between basic science and the economy;
3. A postal questionnaire to all the recipients of BRG grants since 1989;
4. Interviews with scientists to understand how they perceived their own basic work, the way this related to other work they did and, especially, to industry;
5. Case studies of the way research-performing companies in Ireland related to third level research;

6. Some simple analysis of publications by a sample of scientists funded under the Scheme;

7. An administrative review with Scheme management working step by step through the management processes involved; and

8. Desk research.

Thus, this report is a good benchmark for the state of basic research funding in Ireland prior to the injection of additional funding through the HEA PRTLI and SFI (and to a lesser extent IRCSET). The report is aware of this wider scope for its focus:

> "What emerges is a more detailed picture of the relationship between basic science and economic development than has been attempted in Ireland before. It confirms the importance of network relations within and between research communities. A good basic science research infrastructure is necessary if higher-level industrial research and development is to be a reasonable ambition in Ireland. Correspondingly, there needs to be an industrial R&D community in Ireland in order to exploit knowledge in wealth creation."
> [Forfás, 1998a, Introduction]

Thus, whilst many of the influential policy documents mentioned in this chapter allude to the importance of these issues, this report perhaps does more to bring them into focus and initiate an informed debate. It is hard to know how many people read this report, but that many of those who published subsequent reports in the area could have paid greater attention to this well-argued and well-structured report.

Summary of Document Significance

This is one of the few reports that is focused on the potential relevance of basic research to the economy. It recommended that basic research funding from central government should be substantially increased, to IRL£7.6m per year linked to GDP, and that the funded projects should be monitored to ensure that they maintained a high quality as the funding was increased. It argued that this funding could be justified in a number of ways in which basic research has an economic benefit (these are discussed in detail in Chapter 1 of the document):

- New, useful information — research results (but these tend to be long term);
- New instrumentation and methodologies — research capabilities (can benefit production as well as research if transferred from academia to industry);

- Skills, especially skilled graduates — research as training (note that industry hiring from academia can act as a technology transfer mechanism);
- Access to networks of experts and information — research networks (an understanding of how to search for information across a rich network);
- Solving complex technological problems — industry outsourcing research on specific questions to academia; and
- 'Spin-off' companies — direct commercialisation of research from academia.

It also argued that applied research in the university sector needs to be funded by the state, and that the continued funding for the BRG (basic research) should be considered part of a larger integrated funding system comprising research funding and innovation incentives. It also noted that "Since BRG research appears to be performed in laboratories which are less than well funded, an immediate review should be undertaken of university research equipment levels, quality and vintages as a basis for setting a higher budget" [Forfás, 1998a, Chapter 4].

It is interesting to note what actually happened to the BRG scheme in subsequent years. Initially it continued to be operated by Forbairt (renamed Enterprise Ireland) — a strange location for a basic research support mechanism targeting academic institutions. Then in 2002 it was operated jointly by Enterprise Ireland and IRCSET. In 2004 this moved to Science Foundation Ireland and IRCSET. Finally in 2005 it was enfolded in the SFI awards portfolio as the Research Frontiers Programme. This could be seen as the SFI eclipsing the other newly established entities, such as IRCSET, as the only logical choice to administer research grants for academic institutions, even outside of its initial core focus on the two chosen Technology Foresight themes of Information Communications Technologies (ICT) and BioTechnology (Biotech). This relates to the discussion of the development of basic research funding mechanisms that continues as the documents are discussed in the next chapter, Chapter 7, and again in the synthesis in Chapter 8.

Analysis: Evidence of Explicit Contextualisation

The report cites many of the key models and explicitly takes a stand against linear models of invention and innovation:

> "This does not mean that the traditional 'linear' view of invention and innovation namely, that science invents while industry translates inventions into wealth is correct. Quite the reverse. The linear model applies only in rather special circumstances and in a limited range of industries. Rather, for much of the time basic science and in-company research and development people live in rather separate 'worlds'. The

> interplay between them involves a web of interpersonal networks which must flourish if they are to play their respective roles well. It is a precondition for developing an industrial R&D community that there is a well-developed scientific infrastructure. The policy task is to pace the development of the scientific community so that it runs a little ahead of industrial need, without turning it into the kind of high-status white elephant so often found in less developed countries."
> [Forfás, 1998a, Introduction]

The bibliography is provided as a series of footnotes, I quote these below for Chapter 1, removing duplicate citations to the same original text, to give direct evidence for the level of citation of key models:

> "1. E Mansfield,"Academic Research and Industrial Innovation," Research Policy, 20, pp 1–20
> 2. Zvi Griliches,"R&D and Productivity," in Paul Stoneman (ed.), Handbook of the Economics of Innovation and Technological Change, Oxford: Blackwell, 1995
> 3. Ken Arrow (1962),"Economic Welfare and the Allocation of Resources for Invention," in Nathan Rosenberg (Ed.) (1971), The Economics of Technological Change, Harmondsworth: Penguin
> 4. Keith Pavitt,"Academic Research, Technical Change and Government Policy ," in J Krige and D Pestre (eds), Science in the 20th Century, Harwood Academic Publishers, 1995
> 5. Michel Callon,"Is Science a Public Good?" Science, Technology and Human Values, 19, pp 395–424
> 6. Michael Gibbons, Camille Limoges, Helga Nowotny, Simon Schwartzman, Peter Scott and Martin Trow, The New Production of Knowledge, London: Sage 1994
> 8. See, for example, Bengt-Åke Lundvall, National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning, London: Pinter, 1992; RR Nelson, National Innovation Systems, New York: Oxford University Press, 1993
> 9. Walter G Vincenti, What Engineers Know and How they Know It: Analytical Studies from Aeronautical History, Baltimore: John Hopkins University Press, 1990
> 10. OECD, The measurement of Scientific and Technical activities: Proposed standard practices for surveys or research and experimental development, Frascati manual, OECD, Paris, 1981
> 11. This section draws heavily on Ben Martin, Ammon Salter et al, The Relationship Between Publicly Funded Basic Research and Economic Performance, report to HM Treasury, Brighton: Science Policy Research Unit, 1996
> 12. R Nelson and R Levin,"The Influence of Science, University Research and

Technical Societies on Industrial R&D and Technical Advance," Policy Discussion Paper Series No 3, Research Programme in Technological Change, Yale University, Newhaven, Connecticut, 1986
13. Keith Pavitt, "The national usefulness of the research base," paper presented to the Advisory Board of the Research Councils, 16 April 1999
14. Office of the Director of Defense Research and Engineering, Project Hindsight — Final Report, National Technical Information Service, 1967
15. John Irvine, Ben R Martin and Phoebe Isard, Investing in the Future: An International Comparison of Government Funding of Academic and Related Research, Aldershot and Brookfield, Vermont: Edward Elgar, 1990
16. Nathan Rosenberg,"Scientific Instrumentation and University Research," Research Policy, 21, 1992, pp381-390
18. Derek De Solla Price,"The science/technology relationship, the craft of experimental science, and policy for the improvement of high technology innovation," Research Policy, 13, 1984, pp3-20
19. Jacqueline Senker, "Tacit Knowledge and Models of Innovation," Industrial and Corporate Change, 4, pp425-477
20. Michael Gibbons and Ron Johnston, "The role of science in technological innovation,: Research Policy, 3, 1974, pp220-242; C Lyall, The 1993 White Paper on Science and Technology: Realising our Potential or Missed Opportunity? MSc dissertation, Science Policy Research Unit, University of Sussex, Brighton, 1993
21. Ben Martin and John Irvine, "Assessing basic research; some partial indicators of scientific progress in radio astronomy", Research Policy, Vol. 12, 1983, pp61-90.
22. Keith Sequeira and Ben Martin, Physics and Industry, Science Policy Research Unit, University of Sussex, 1996; Erik Arnold and Peter Senker, Designing the Future: The Effects of Interactive Graphics CAD on Skill Requirements in the Engineering Industry, Watford: Engineering Industry Training Board, 1982
23. Derek de Solla Price, Little Science, Big Science, New York: Columbia UP, 1963
24. Diana Hicks, "Published Papers, Tacit Competencies and Corporate Management of the Public/Private Character of Knowledge", Industrial and Corporate Change, 1995, 4, pp401-424
25. A Arundel, G van de Paal and L Soete, Pace Report: Innovation Strategies of Europe's Largest Firms: Results of the PACE Survey for Information Sources, Public Research, Protection of Innovations and Government Programmes, Final Report, Maastricht: MERIT, University of Limburg, 1995
26. Erik Arnold and Ken Guy, Evaluation of the IT4 Programme, Final report of the evaluation of the IT4 Programme of pre-competitive, collaborative R&D in Information Technology, SPRU and Technopolis, Stockholm: IT4 Delegation,

1992; similar results were found for the corresponding UK 'Alvey' Programme, see Ken Guy, et al, The Evaluation of the Alvey Programme for Advanced Information Technology, HMSO: London, 1991

27. Keith Pavitt, "National policies for technical change: Where are there increasing returns to economic research?" Paper prepared for the Colloquium on Science, Technology and the Economy, organised by the US Academy of Sciences at the University of Irvine, 1995

28. Only firms performing formal R&D and having sales in excess of ECU 1.5 billion were included in the sample. The response rate was 54%

30. D Massey, P Quintas and D Wield, High-Tech Fantasies: Science Parks in Society, Science and Space, London: Routledge, 1992

31. Ken Guy, Erkko Autio, Tomi Laamanen, Bill Wicksteed, Tero Kivisaari, Vesa Jutila, The Evaluation of the Otaniemi Science Park Cluster, Technopolis, Brighton, 1995

32. Rikard Stankiewitz, Academics and Entrepreneurs, London: Francis Pinter Publishers, 1986; Erkki Autio, Sympletic and Generative Impacts of New Technology-Based Firms in Innovation Networks, Doctoral Dissertation, Institute of Industrial Management, Helsinki University of Technology, 1995

34. ... See also Guy, K, et al, The Evaluation of the Alvey Programme for Advanced Information Technology, HMSO: London, 1991

35. Erik Arnold, Patries Boekholt, Patrick Keen, Jez Lewis and James Stroyan, Evaluation of the Technology Transfer and Partnership Programme, Dublin: Forfás, 1997

36. S Lowe and R Rothwell, The Sussex Technology Transfer Centre: A Background Report, Brighton: Science Policy Research Unit, 1987

37. J Senker and W Faulkner, "Public-private research linkages in advanced technologies", paper presented at the Indo-British Seminar on Industry-Institute Interaction, British Council Division New Delhi, March 6-7 1995

38. Pari Patel, "Are large firms internationalising the generation of technology?" IEEE Transactions on Engineering Management, 1996 (forthcoming)

39. P Stoneman, "Overseas financing for industrial R&D in the UK," paper presented to Section F of the British Association for the Advancement of Science, Sheffield, 1989

40. J H Taggart, Determinants of the Foreign R&D Location Decision in the Pharmaceutical Industry, University of Strathclyde Business School Working Paper No 89/7, 1989

41. The best review of evidence about the effectiveness of 'technology push' and 'demand pull' in promoting innovation is DC Mowery and N Rosenberg, "The Influence of Market Demand upon Innovation: A Critical Review of Some Recent Empirical Studies", Research Policy, 8, 1978"

[Forfás, 1998a, Footnotes to Chapter 1]

This demonstrates direct reference to three of the four models discussed in Chapter 4: linear models (directly in the text quoted in the previous paragraph, rather than by citing Bush or another authority), National Systems of Innovation (both Lundvall and Nelson are cited, see footnote 8), and Mode-2 (Gibbons is cited, see footnote 6). Only the Triple Helix model is not discussed, perhaps because the first international Triple Helix conference was held in Amsterdam in 1996, and its key outputs were not published as papers and a book until 1997 and 1998 (e.g. [Etzkowitz and Leydesdorff, 1997]). Many other models more relevant to business aspects of invention and innovation than knowledge production are discussed. The use of terminology (such as basic research, applied research, strategic research and experimental development) derived from the OECD Frascati Manuals is explicitly acknowledged (see footnote 10). It is notable that the document even refers to an MSc thesis produced in the Science Policy Research Unit (SPRU), University of Sussex in the UK (see footnote 20) as well as a number of SPRU reports (see footnotes 11, 22, and 36). All of this evidence as a whole indicates an awareness of the research activity around science policy grounded in solid academic citation. One could state that this report, of all those studied so far, is most firmly placed within a wider academic context of work on knowledge production and of industrial innovation policy, despite the very high quality of other texts. However, some bias towards this opinion might be admitted here, as this report is the one that is most focused on the difficult issue of how basic research relates to economic impact through a model of research and innovation, i.e. the core context of this thesis — contextualisation of science research.

Like CIRCA [CIRCA, 1996] this BGP review acknowledges the work of Pavitt in justifying public investment in basic research activities:

> "Overall, our findings in this Chapter support Pavitt's claim that 'Contrary to common belief, the main economic benefits of basic research are not knowledge directly applicable in a narrow range of sectors, but background knowledge, research skills, instruments and methods that yield economic benefits over a much broader range of sectors.' "
> [Forfás, 1998a, Chapter 1] (see footnote 13 above for Pavitt reference)

Analysis: Evidence of Implicit Contextualisation

In this report the discussion of models of knowledge production and innovation is so explicit that the requirement for an additional analysis of implicit contexualisation becomes unnecessary. The mode of discourse in the document is to make

explicit its references to the scientific literature when discussing each concept as illustrated in the previous subsection by the extensive footnotes for Chapter 1.

Analysis: Summary

This document is focused on analysing the benefits to society of the government funding basic research activities. The document explicitly addresses the literature around models of research and innovation, providing perhaps the best bibliography of this area of any of the policy documents discussed in this chapter or the next, with direct citation of all of the theoretical models discussed in this thesis, other than the Triple Helix. The document highlights and rejects linear models of research and innovation. The document argues in favour of basic research investment, primarily justified through indirect benefits such as the development of background knowledge, the development of research skills, instruments and methods, and the wider diffusion of these types of impact across the economy, rather than a direct link between particular research outputs and economic exploitation.

6.4 Findings: Documents 1995–2000 Summary

The set of documents analysed in this chapter is dominated by the hugely influential STIAC Report, also known as the Tierney Report, published in 1995 [STIAC, 1995], that set in motion the radical change in funding policy that was implemented, with almost unilateral consensus, despite three changes in government (c.f. Appendix C): Fianna Fáil with Labour (1993–4), Fine Gael with Labour and the Democratic Left (1994–7), and Fianna Fáil with the Progressive Democrats (1997–2002). All the major themes of the Tierney Report are picked up in the subsequent White Paper [OST, 1996], and the policy is then driven by the recommendations of this document. Although the Tierney Report came from a very economic background, and was commissioned by the Department of Enterprise, it was very clear on the need for investment in all forms of research and development activity as part of developing an Irish National System of Innovation. It could be argued the other key report was the CIRCA Report [CIRCA, 1996], documenting the Department of Education's and the Higher Education Authority's response to this changing environment in favour of increased investment in academic research.

The documents seem to show that the development of an integrated STI strategy in Ireland has its main impetus in the Department of Enterprise, Trade and Employment (through its various name changes) rather than in the Department of Education. The White Papers published by each department in the mid-1990s: Enterprise [OST, 1996], Education [DES, 1995] reflect this in the lack of any em-

phasis on R&D in the latter. However, despite the drive for an STI policy from an economically oriented department, the policy as it evolved was clear on the need to develop all aspects of a healthy National Systems of Innovation (NSI), in particular making a strong case for increased funding for basic research in higher education institutions. Thus the NSI approach is cited frequently, especially by the Tierney Report [STIAC, 1995] and the STI White Paper [OST, 1996]. One other report that stands out is the analysis of the Basic Research Grants [Forfás, 1998a], a programme that had been operating prior to this shift in policy. This analysis covered the period from 1989–1996. The interesting element of this report is the depth of understanding of the academic debate around models for the research side (knowledge production) and the innovation side of the debate. Both CIRCA [CIRCA, 1996] and this review include Pavitt's justification of basic research investment as a key citation.

The analysis here shows that the levels of contextualisation present in the policy documents do not necessarily relate to their recency; the older documents are as likely to have made explicit and implicit links between the research activity and the expected economic benefits, to adopt models that are non-linear. Indeed, the more academic rigour used in the reports (particularly of note are the Tierney Report [STIAC, 1995], the CIRCA Report [CIRCA, 1996], and the Forfás review of the BRG [Forfás, 1998a]) the more likely is the presence of explicit references to the core models of research and innovation.

It should be noted here that a large number of other texts were considered but ultimately not included in the formal analysis because of their lack of any explicit (and very limited implicit) references to these models. These include the published annual reports of Enterprise Ireland and of the Higher Education Authority.

Overall one can see a strong theme, led by the Department of Enterprise, of the promotion of increased investment in research as part of developing an Irish National System of Innovation (NSI). This NSI approach is thus the dominant model cited explicitly, with Nelson the key common author cited.

Chapter 7

Analysis of Texts: 2001–2008

7.1 Introduction

This chapter analyses a series of texts that date from 2001 to 2008, arguably based on the policy framework for the increased investment established by the documents analysed in the previous chapter, Chapter 6.

7.2 Policy Implementation Texts

7.2.1 Skilbeck 2002: The University Challenged

Summary of Document

The report opens with a foreword by Roger Downer, Chairman of CHIU (Committee of the Heads of Irish Universities — more recently renamed as IUA Irish Universities Association) and Don Thornhill (Chairman of the HEA). The work was commissioned by CHIU and the HEA to facilitate a higher level analysis of the threats and opportunities facing Irish universities.

The report is divided into four major sections, comprising an Introduction followed by Parts I, II, and III. PART II makes up the bulk of the document:

1. Introduction: The Nature of the Enquiry (6 pages);
2. PART I – Directions: An Overview of International Trends and Issues (19 pages);
3. PART II – The Trends and Issues Examined (90 pages);
4. PART III – Focusing the Challenge: The Universities of Ireland (21 pages).

> "In the preparation of this report, two purposes have been paramount: first, to offer an overview and appraisal of trends and issues arising in the international domain of university education, broadly defined to include the functions of teaching, learning, scholarship and research; second, to focus these trends and issues in possibilities for action for consideration by the Irish university system. The intent is less to survey the field than to identify concerns and issues that are at the heart of current international debates. It is hoped thereby to assist universities to further their ideas and plans for their own future development by holding a mirror to the changing world of higher education."
> [Skilbeck, 2002, p. 18]

Summary of Document Significance

This document is perhaps the most articulate and extensive statement of the university sector's view of the debate on the future for higher education in Ireland, framed as an objective external expert analysis. Thus it is a significant contribution to the policy debate, providing a highly citable reference for many key opinions and concerns.

Not surprisingly, the challenges for the Institute of Technology sector are not very well discussed in the document: the remit was to focus on universities in Ireland. The document contains one brief discussion of the issue of a binary system, "The establishment of the second tier, alternatives to universities, strongly encouraged and recommended by the OECD at the beginning of the '90s (OECD, 1991) has had some unanticipated or at least unplanned-for consequences." [Skilbeck, 2002, p. 62]. Some of the institutes of technology went on to discuss issues relating to the binary system with Skilbeck and the subsequent analysis published the following year [Skilbeck, 2003] was more critical of the binary system. OECD [1991]

When it was published the document was heralded as a significant contribution to the policy debate, and indeed it stands up well today as a clear yet scholarly articulation of the range of issues facing universities in Ireland at the start of the twenty-first century. The report was published after the extensive policy discussion about the best way to proceed in the 1990s had concluded, and after the Technology Foresight exercise had made its recommendations. Skilbeck stands as a reflection of the universities' view, just as the large investment in research is beginning with the first round of the HEA PRTLI and the establishment of Science Foundation Ireland.

Analysis: Evidence of Explicit Contextualisation

This is a well researched and scholarly text with a 28-page bibliography and references section. The main theoretical model that is used to pull together the text, especially in the sections where research is discussed, is "The four scholarships of academic life: discovery, interpretation, application, teaching (Boyer, 1990)" [Skilbeck, 2002, p. 73]. Thus there is a tendency to draw back from following a line from research towards development and innovation (the terms "research and development" and "R&D" are used rarely, and never to introduce a section where the epistemological issues of knowledge production and its exploitation are discussed. Without such a section it is hard to cite an explicit reference to the linear model, so discussion of the potential use of a linear model will be deferred to the next section, where less direct evidence may be cited.

As this thesis has argued, the theory of National Systems of Innovation was in many senses the core driver of the Science Engineering and Technology policy documents of the 1990s. Despite this, NSI is not explicitly discussed by Skilbeck as a concept, though one of Lundvall's books on the learning economy is listed in the bibliography. There is an understanding of the higher level broad sweep of the NSI argument, and a caution about the ease of linkage between universities and innovation "Geiger (2000) notes important difference in patterns of interaction between universities with large and with small firms. Most academic staff have but limited industry experience and the history of technology parks and start-up companies in many universities in other countries does not present a picture of consistent success. There are also issues, alluded to above, of the very unequal access within institutions to research funds, industry links, consultancies and commercial opportunities. The paths to be followed by universities in building the knowledge-based society and economy will be difficult. Study of experience in those countries where universities are endeavouring to follow these paths would be of great benefit in the new Irish funding environment."[Skilbeck, 2002, p. 94].

The Triple Helix model, and Etzkowitz are not mentioned at all. There is some discussion about the complexity of the pressures upon universities from the public sector via funding controls, and from industry, but no discussion of formal models of this interrelationship.

Gibbons and Mode-2 are formally acknowledged, within a discussion of the complexity of the linkages between universities and industry: "The old (Humboldtian) idea of university research, largely contained within and advanced through the disciplines and academic departments, has come under increasing strain through the emergence of so-called mode 2 or network/ partnership research (Gibbons, 1995; Gibbons et al, 2000) and issues over knowledge ownership and intellectual property rights. These have come to the fore in mode 2 type partnerships and alliances — defined as productive working relations between university

researchers, those in specialist research institutes and industry and commerce — and between this networked research community and the entrepreneurial commercialisation of the products of research."[Skilbeck, 2002, p. 93]. Four of Gibbons' publications are listed in the bibliography. Gibbons [1995] Gibbons [2000]

Analysis: Evidence of Implicit Contextualisation

The Skilbeck report was written from the perspective of the universities, just as the new large investment in research in Ireland was beginning. It is worth quoting the full text of his analysis of this process, though it is a lengthy quotation:

> "The 1999 National Development Plan for research, technology development and innovation sets out ways to enhance research and development in higher education through a major investment programme. The Plan includes provision of IR£ 560 million for the Technology Foresight Initiative, which has commenced with the establishment of the Science Foundation of Ireland under the aegis of Forfás. There are four pillars of support for research and development: the existing unified teaching and research budget allocated by the Higher Education Authority to the universities as a block grant; the funding of individual research proposals and projects following competitive application processes and peer review assessments; the funding of institutional research strategies on a basis of competitive peer-reviewed evaluation; 'mission oriented' research where institutions and researchers respond to invitations for research proposals in priority areas identified by government. Described by Dr Don Thornhill, Chairman of HEA, as 'the most important and exciting development that has ever taken place in the history of research in Ireland.' (The Irish Scientist Yearbook 1999, p.28), with further funds from other sources, this dramatic augmentation of the research capability of the tertiary institutions is a challenge to demonstrate world quality, the capacity to develop longer term strategies for R&D and ability to liaise, cooperate and share resources nationally and internationally. While there is also an expectation that research will contribute to innovation in ways that yield economic pay-offs, the programme is open to basic research in the sciences and to the humanities and social sciences where results and applications, albeit of intellectual and social significance, would not, or not necessarily, be judged by economic criteria. That these considerations are being taken into account is reflected in the wide variety of allocations made in the first round. This policy is consistent with the arguments considered in earlier parts of this report

> for maintaining in universities a breadth of studies at the frontiers of knowledge. However, the programme does raise major challenges for the universities. The first, discussed above, is the need for the universities to demonstrate quite convincingly that an entirely separate system of research institutions independent of universities is not necessary and would be a waste of resources. Several further issues need addressing: concentration in already strong areas or the development of a very broad research base; the development of infrastructure, and management strategies; connecting research with teaching including the much-needed expansion of post-graduate programmes and student numbers; industry-community-partnerships; cross-institutional/cross-national collaboration; attracting researchers of the necessary calibre and providing career routes for them."
> [Skilbeck, 2002, p. 141]

It is interesting that this does not offer an analysis of what should be the best structure to promote the creation of new knowledge that could lead to Ireland's economic benefit, but instead states that the universities must demonstrate that research institutions separate from the universities are not necessary. So the context for Skilbeck's observations seem to be not so much neutrally observing the environment, but arguing forcefully for universities to stake their claim.

Surprisingly for a report focused on the challenges for universities at the turn of the century there is little discussion about the nuances within research, and much more focus upon the higher level tension between teaching and research within a single institution and sometimes by the same staff. Thus there is less room to discern an implicit statement of a linear model: basic research, through applied research to industrial development and exploitation in a linear fashion. However, basic and applied research are mentioned in passing, but it could not be argued that Skilbeck has advocated a linear model either explicitly or implicitly.

The lack of an explicit engagement with the theory of National Systems of Innovation has been discussed above. It should be noted though, that through discussion of the Irish policy context, some of these ideas do show through into Skilbeck: "For Ireland, the Technology Foresight project of the Council for Science,Technology and Innovation, envisages a re-positioning towards a knowledge-based economy with complex interrelationships and partnerships among industry, government, higher education and various social actors. The government has accepted the case for research excellence in establishing the Technology Foresight Fund (taken up again in Part III)." [Skilbeck, 2002, p. 94].

There is no direct or indirect evidence for an agreement with a Triple Helix perspective of research and innovation.

Skilbeck is explicitly aware of the challenge that Mode-2 could pose to universities, but there is no further indirect evidence in the report, beyond his citation of Gibbons [Skilbeck, 2002, p. 93] to deepen this analysis.

Analysis: Summary

Although Skilbeck's report does have some direct citation of the key theoretical models that inform this thesis (e.g. Gibbons' Mode-2), the report does not intellectually engage with the problem of finding a model for the research and innovation process, and then looking at the suitable institutions, funding mechanisms and overall policy needed to foster that model. Instead, Skilbeck in the report assumes a defence of the the universities from external pressures and assumes their right to play a key role in any such processes, without putting their core ethos at risk.

7.2.2 ICSTI 2002: Measuring and Evaluating Research

Summary of Document

This report [ICSTI, 2002], coming from the Irish Council for Science Technology and Innovation (ICSTI), represents a response to the new funding environment, and the need for the state to develop a solid set of metrics to measure the effectiveness of its new funding programmes. The report's introduction is clear about its intent:

> "Recent years have witnessed a sea-change in Irish public policy towards Science, Technology and Innovation (STI), which is now regarded as central to this country's continued economic and social development. The key role of STI policy is signalled in the National Development Plan 2000–2006, and reflected in the initiatives of the HEA, Science Foundation Ireland, Forfás, Enterprise Ireland, and the full range of State agencies supporting the evolution of Ireland as a 'knowledge-based society'. This new policy environment brings with it many challenges, one of which is to develop mechanisms so that public support for STI can be prioritised, and so that the outcomes of such support can be measured and evaluated. This is important, not only for policy makers who are responsible for allocating public expenditure and for the tax payers who finance it, but also for the scientific and technological community in Ireland, insofar as they seek to provide evidence to the wider public of the social and economic benefits of support for STI.

> These concerns, of relatively recent prominence in Ireland, have been the focus of much international effort in the science policy community, as governments world-wide respond to the need for new indicators and evaluation techniques for knowledge based societies. This report reflects that work, and its relevance to the Irish context, and provides a structured survey of the principal indicators and techniques used internationally to measure STI policy activities and to assess their impacts."
> [ICSTI, 2002, p. 3]

Stepping back from models the report comments on the pressures for accountability of this form of public funding, and that this could be part of the wider issue of a new form of interaction between science and society:

> "The initiation of reviews of the effectiveness of science policy by politicians and other policy makers has arisen for a number of reasons. There has been external pressure on available funds for these activities and, consequently, renewed calls for increased accountability for their use as well as internal pressure to target resources more effectively. More than this, the demand for the review and assessment of government research programmes appears to stem from an interaction between these usual pressures and a longer term phenomenon referred to elsewhere as 'the renegotiation of the science/society contract'."
> [ICSTI, 2002, p. 6]

Whilst the aim of this report is to propose evaluation metrics for research and innovation in Ireland, the authors are wary of the dangers involved:

> "The limitations of simplistic, 'cause and effect' type approaches to the evaluation of research activity need to be explicitly recognised. Research by its nature is uncertain, novel and risky. Its impacts can be long term, unexpected, or fail to materialise. They can be greatly affected by many external factors outside the scope of the initiative which supported the research. As such, it is important that evaluation and monitoring activities are supportive of these phenomena while also providing useful feedback to stakeholders on the nature, merits and likely impacts of research activity under review."
> [ICSTI, 2002, p. 7]

Summary of Document Significance

The recommendations of this report are:

"We recommend:

- That expertise in indicators and evaluation techniques for STI policy be more widely embedded in public policy agencies in Ireland, to more fully reflect the centrality of this domain of policy to economic and social development, by
  - The continued development and use of such techniques by specialists agencies such as Forfás, the HEA, and SFI and evaluation units involved in STI activities,
  - The dissemination of information on, and the results of, such techniques in the wider policy community, through publications and conferences/seminars on these themes,
  - Consultation with the scientific and technological communities as to the evaluation approaches adopted or under consideration.
  - The much wider use by funding sources (typically government departments) of a formal ex-ante evaluation prior to approving the introduction of any new or revised STI initiatives.
  - The provision of a specific allocation for the costs of monitoring and evaluation within the overall budget for each STI support programme.
- That the production of indicators and the conduct of evaluative exercises should take full advantage of the range of techniques available, or under development internationally i.e. a 'portfolio approach' is recommended, rather than the reliance on unduly simplistic, one-shot summary measures.
- That the choice of indicators and evaluation techniques be generally governed by an appreciation of the underlying complexities and uncertainties of scientific research and technological development, the resource costs of such exercises, and the impacts they may have on the incentives of researchers."

[ICSTI, 2002, p. 20]

The report's main significance is that it attempts to explicitly link the higher policy level discussions with the underlying pragmatic issue of how to measure and evaluate research. It seems that this report has not had a high impact, with most metrics continuing to be driven by the OECD processes.

Analysis: Evidence of Explicit Contextualisation

The report acknowledges that any metrics must be based on the solid theoretical foundation of an understanding of the rationale for the public funding of research. Chapter 2 of the report directly addresses this question, and is thus forced to explicitly confront issues of the relevance of research and its potential economic impact. In the first section, 2.1, that is titled "Market failures, public goods and the linear model of innovation," the report dismisses linear models as simplistic:

> "However, it is increasingly recognised that this 'public good' view of scientific knowledge is an over simplification. It is a traditional or neo-classical economic argument which relies on an unduly simplistic analysis of scientific and technological activities — a so-called linear model of innovation — which views innovation as a step-by-step development from initial invention (basic research), through applied research and development to the ultimate marketing of new products."
> [ICSTI, 2002, p. 5]

The next section goes on to explore the alternative model of a system of innovation, acknowledging the role of the Tierney/STIAC Report in Irish policy formation around this issue:

> "This new evolutionary model is commonly referred to as the 'systems of innovation' approach. Strengthening the Irish system of innovation has been a national policy objective since the STIAC Report (1995) and the White Paper on Science, Technology and Innovation (1996), and is the key rationale behind major recent public investments in research, including Science Foundation Ireland and the HEA Programme for Research in the Third Level Institutions."
> [ICSTI, 2002, p. 6]

Ironically, despite this arguably astute analysis the formal references in this report are very few:

> Kane, Aidan (2001a) "Rationales for Science, Technology and Innovation Policy in Ireland", background document for ICSTI Task Force, May 2001.
>
> Kane, Aidan (2001b) "Indicators and Evaluation Techniques for Science, Technology and Innovation", background document for ICSTI Task Force, May 2001.

> Mansfield, E. (1998) Academic research and industrial innovation Research Policy 25 pp 773-776.
>
> Salter A.J. and Martin B.R. (2001) The economic benefits of publicly funded basic research: a critical review, Research Policy 30 pp 509-532.
> [ICSTI, 2002, p. 21]

It should be noted that Aidan Kane was one of the members of the task force who authored the report, so two of the references are to the authors' previous publications.

Analysis: Evidence of Implicit Contextualisation

It could be argued that this report's analysis of alternative models is somewhat simplistic and that it almost assumes a dialectic approach contrasting a neo-classical linear model (of research and innovation) with an evolutionary/institutional one:

> "The underlying model of the innovation process on which an indicator/evaluation is based—linear/neo-classical or evolutionary/institutional, for example;"
> [ICSTI, 2002, p. 10]

This is reflected in the types of metrics proposed, where one set (input/output approach) is linked to the linear model, and another set (throughput approach) is linked to the institutional model.

Analysis: Summary

This document is very aware of its theoretical context, and explicitly rejects simplistic neo-classical economic arguments based on linear models of research and innovation in favour of more evolutionary models such as National Systems of Innovation.

7.2.3 HEA 2002: Creating and Sustaining the Innovation Society

Summary of Document

Published in July 2002 this document, *Creating and Sustaining the Innovation Society* is the HEA's contribution to the emerging debate on an integrated framework for a national policy on research and technological development.

> "The Authority is engaged in developing a vision and strategy for higher education in Ireland based on a process of consultation with key stakeholders.
> The place and development of research in the higher education system is an essential part of the vision and the strategy.
> This discussion document has been prepared by the HEA as part of its strategic development process. It has also been prepared as the Authority's initial contribution to the work of the Commission established by the Government under the aegis of the Irish Council for Science, Technology and Innovation (ICSTI) to develop a framework for national policy for research and technological development.
> The Authority is also about to embark on a process of consultation with key stakeholders as part of its strategic planning exercise."
> [HEA, 2002, p. 3]

The document comprises six chapters, an executive summary and a number of appendices. It analyses in some detail the public sector structures in a number of countries to support public research funding within a national innovation system. It concludes that there is no one successful model that Ireland can simply adopt, but that instead Ireland should develop its own approach keeping some of its existing structures, and emphasising overall coordination under a centrally agreed political structure, but while maintaining a diversity of actors and approaches.

Summary of Document Significance

This document summarises the situation in Ireland after the new research money has been awarded, but before the high level monitoring and policy structures have been implemented. Thus the funding from HEA PRTLI Cycles 1, 2 and 3 has been awarded (though not yet fully spent, as some of the programmes have a 5-year duration), the SFI has made a number of awards for Principal Investigators (PIs) and Centres for Science, Engineering and Technology (CSETs), and the two research councils have been established — IRCHSS and IRCSET. Thus the document is interesting from the perspective of this thesis as a snapshot of the key issues at this critical juncture.

The overall thrust of the document towards the need for an agreed political structure, crossing government departments, to manage research and innovation policy, can be seen as part of an emerging consensus, as such structures were subsequently established with support from all the agencies involved. It is harder to judge how influential this document was in this process, but certainly it would have been in line with the thinking of the Department of Education and Science (DES) given the strong links between the HEA and the DES.

Ironically, the SFI has developed a reputation for a much more stringent review process for its ongoing funding than the HEA has done, perhaps because the core focus of HEA funding is on the institutions, and the core focus of the SFI funding is on the individual researchers, and the PIs in particular. It is certain that the emphasis of the HEA PRTLI funding proposal evaluation process on institutional strategies, and on institutional research strategies, has had a profound impact on the institutions, and has led to the development of coherent institutional strategies and coherent institutional research strategies, that did not exist before this process.

The document explicitly criticises the take-up of the Tierney Report's recommendations:

> "Provisions for national co-ordination and resource allocation were outlined in the 1996 White Paper on Science and Technology and functions in this area are assigned by legislation to the Minister for Enterprise, Trade and Employment and to Forfás. The White Paper also proposed that the Government would adopt an integrated process for prioritising S&T spending which would be convened under an interdepartmental committee, under the direction of a cabinet committee.
>
> The White Paper also envisaged that responsibility for national co-ordination of science and technology across Ministries would be assigned to an individual office — the Office of Science and Technology (OST), located within what is now the Department of Enterprise, Trade and Employment.
>
> The White Paper also provided for an independent science policy advisory function to be carried out by ICSTI (the Irish Council for Science, Technology and Innovation) which is legally constituted as a sub-board of Forfás, a statutory agency reporting to the Department of Enterprise, Trade and Employment.
>
> Finally, the White Paper also envisaged overarching co-ordinated mechanisms involving an interdepartmental Committee on Science and Technology, and a Cabinet Sub Committee on Science and Technology.
>
> These arrangements were never fully implemented. The Cabinet Sub Committee has never met and the Inter Departmental Committee relatively infrequently. Furthermore, the structure as envisaged has been overtaken by subsequent policy developments. The most significant of these were the much enhanced role in research policy and funding undertaken by successive Ministers for Education and Science since 1997, the launch of the PRTLI in 1998, the setting up of

the research councils in 2000 and 2001 respectively, the establishment of SFI and the recent decision made by the Tánaiste and Minister for Enterprise, Trade and Employment that she would take on direct responsibility for science and technology policy.

However, these developments do not explain why the 1996 arrangements were not effective. The reasons are more fundamental and had more to do with the difficulties which resulted from assigning oversight and review functions to the Department of Enterprise, Trade and Employment and its agencies, which also have specific sectoral responsibilities for industrial and private sector services development and regulation. There are inevitable tensions between pursuit of a sectoral mission (notwithstanding its importance) and the carrying out of oversight and review functions. With hindsight, there was a serious shortcoming in the design of the overarching structure. The outcomes were confusion in the research community about overarching policy objectives and concerns about responsibility and functions among other departments and organisations.

Redressing this critical shortcoming poses formidable difficulties for system design. Our recommendations in Chapter 6 attempt to meet these challenges.

The second reason is that the proposed process of settling expenditure estimates through a Cabinet Committee does not accord with the established practice of agreeing Exchequer expenditure estimates. These are determined by the outcome of bilateral negotiations between the Minister for Finance and 'spending' Ministers within the constraints of a fiscal framework agreed at Government. This process is already complex and sensitive and did not adapt to a further overarching input. A Cabinet Committee could have played an important role in respect of setting policy directions but this did not turn out to be the case.

New arrangements are needed. Science, technology and research are horizontal functions. They need horizontal mechanisms to co-ordinate them, not sectoral ones, as is currently the situation. In our view, oversight and overall co-ordination for research, development and innovation is a central government function, best exercised in a way which ensures a distinction between policy oversight on the one hand and control on the other."
[HEA, 2002, 5.47–5.55 pp. 88–90]

This is a frank acknowledgment of the difficulties in implementing some of the STIAC recommendations, including the admission that it is very difficult to

modify the time-honoured mechanisms for allocating budgets to departments.

There is also the implication that the DES's and HEA's requirements were side-lined, despite the DES's increasing role. The report includes some criticisms of the SFI:

- "The principles and criteria in Chapter 3 help us to identify five major shortcomings: [...] A degree of confusion about the mission and activities of SFI and its future role in the funding of basic research"
  [HEA, 2002, 5.44 p. 87]

- "We are concerned that the technology transfer process aspects may be lost, unlike the UK, where Foresight is an important way of engaging industry with the research base. We acknowledge the steps recently taken by SFI through the Science, Engineering and Technology campus-industry partnerships initiative."
  [HEA, 2002, 5.61 p. 92]).

Overall these criticisms read like the iceberg peaks of a deep conflict between the HEA and SFI over the control of basic research funding, with the HEA seeking to push the SFI back into the innovation box, away from the basic research funding box. The document recommends just that: "Reviewing and refocusing the roles of EI and SFI in technology transfer and commercialisation processes and in the building of research and innovation capabilities in the business sector."
[HEA, 2002, p. 14]

Analysis: Evidence of Explicit Contextualisation

The document sets out to justify combining the the HEA block grant to universities, and of the PRTLI research funding programme (awards made under Cycles 1, 2 and 3 are reported) as part of building up the skills base in Ireland for doing research, as part of a national innovation system. The block grant funds the staff, with staffing levels mainly justified in terms in terms of undergraduate student numbers, but in so doing enables research activity of those academic staff. This baseline research funding is then augmented by competitive bids for research funding from the PRTLI programme, with allocation based on academic merit and track record of the applicants.

> "The Authority is convinced that Ireland must build competitive advantage based on the skills and knowledge of our people, as the primary sustainable long-term resource available to the economy and our society. This will require a sustained commitment to basic research, largely because engagement in basic research and exposure to

> its methods, enhances the quality of human resources for the economy. Because many of the benefits of basic research are embedded in human skills and experience, and are not carried in codified formats such as intellectual property, the contributions of basic research to the economy are delivered, inter alia, through people. The link between basic research and education and training is central to the whole relationship and to the capacity of the innovation system, particularly in the case of an economy like Ireland, with, in international terms, a relatively small industrial base."
> [HEA, 2002, 1.19, p. 24]

The later footnotes in Chapter 1 cite a number of key authors in the analysis of research and innovation, all justifying some form of return on investment:

> "7 Jorgenson Dale W. "Investing in Productivity Growth" in Technology and Economics. Washington DC., National Academy Press 1991 p59.
> 8 Mansfield, E. Academic Research and Industrial Innovation. Research Policy 20, pp1-20.
> 9 Francis Narin, Kimberly S. Hamilton, and Dominic Olivastro. "The Increasing Linkage Between US Technology and Public Science", Research Policy 26(3) 1997 317-330
> 10 See, for example, a study of basic research in Ireland published by Forfás and carried out by Technopolis and Keith Pavitt-An Evaluation of the Basic Research Grants Scheme operated by Forbairt. Undated (circa 1997)"
> [HEA, 2002, pp. 24–25]

The first footnote (7) is cited to justify the assertion that "R&D, according to these studies, has accounted for between 12 and 25 percent of annual growth in productivity during the port-World War decades in the US." The next footnote (8) is cited as an "estimated a 28% social rate of return on investment in academic research." The next footnote (9) is cited to support the claim that there is "evidence also of a growing dependence of private technology on public science." The final footnote (10) is cited as evidence that "there are many examples in the literature of considerably higher rates of return." Note that the last of these footnotes (10) is a citation for a document analysed in the previous chapter [Forfás, 1998a] of this thesis.

Chapter 2 has a section on *A National Innovation System*, and so can be said to explicitly support this model, dominant since the Tierney Report in 1995 [STIAC, 1995].

Analysis: Evidence of Implicit Contextualisation

Note that whilst accepting the overarching model of the Innovation System, with its economic imperatives, this document distances itself from the full implications of this model:

> "It would be a major policy error, with serious negative moral and ethical implications, if higher education and research system activities were subordinated to economic activities. Education and research must remain true to their higher order missions of enhancing the capacity of each individual in the search for personal fulfilment, understanding and development. We refute any view that there is a choice to be made between so-called "utilitarian" and "higher order" objectives for education and research. Such a view is incorrect and perhaps dangerous. Both objectives must co-exist. We need to strive for a holistic education and research system which provides us as individuals, and as a society, with the means to make our contributions in the economic, social and cultural domains of our society, but which also provides us with the means to achieve our personal goals for self realisation and fulfilment."
> [HEA, 2002, 2.26 pp. 37–38]

Thus the tone of the report is generally one of defence of an implicit linear model where basic research needs freedom to operate outside the pressures of considerations of use. So there is a tension between this more traditional linear view and the acceptance of the innovation systems model.

In addition to these models, in Chapter 2 a form of 'triple helix' is mentioned:

> "The Authority is committed to enhancing the link between teaching, research and learning-a triple helix of interlocking connections. National policies in respect to education, and in particular to the quality of educational output, would be damaged were these linkages to be disrupted or weakened. The Authority is convinced that research exposure is critical in the formation of human capital and has a significant influence on the quality of part of the central mission of the Department of Education and Science and the funding of research must remain a responsibility of the Department."
> [HEA, 2002, 2.34 p. 39]

This is quite different from the sense in which the term is used by Etzkowitz [Etzkowitz and Leydesdorff, 2000], so here it is not attributed as being an implicit reference implying support of the Triple Helix model itself.

Analysis: Summary

This report, whilst mentioning National Systems of Innovation, is focused on an implicit model of justifying investment in research for its own good, rather than for an economic purpose. It argues that research funding should come under the Department of Education and Science (DES) rather than under the Department of Enterprise, Trade and Employment (DETE), and it explicitly criticises the Science Foundation Ireland (which is funded under the DETE) for being unclear about its mission.

7.2.4 Forfás 2004: Building Ireland's Knowledge Economy: The Irish Action Plan for Promoting Investment in R&D to 2010

Summary of Document

This document is a report to the Inter Departmental Committee on STI. It was produced by the Enterprise Strategy Group (ESG), and delivered in July 2004. It is sometimes referred to as *The National R&D Action Plan*. This document covers statistics relating to the issue of improving investment in Research & Development (R&D) both by government in higher education institutions and other public actors, and by businesses (e.g. HERD and BERD), see also Chapter 3.3 for a discussion of these terms. The report argues the case that Ireland, despite increased investment in the 1990s, lags behind the OECD averages for such investments, and in particular lags behind the leading countries in the world (where Ireland would like to be positioned). The report concludes:

> "Ireland has the potential to achieve a step change in the performance of R&D over the period to 2010. Ireland has a strong enterprise base and the potential to increase its R&D capability and absorptive capacity. It also has a growing public research base. The determinant of Ireland's future economic well-being will be its success in stimulating business to do more R&D and fostering effective linkages between enterprise and academia.
>
> As a small, open economy, putting R&D at the heart of our economy, increasing productivity and competitiveness through R&D, creating an environment in which innovation happens by national design rather than individual fortune, will sustain this change and enable the standards of living and quality of life for our people to rise."
> [Forfás, 2004, 5.1–5.2 p. 30]

The detailed analysis of how research investment increased over the 1990s is very useful.

Summary of Document Significance

This report is viewed as an important stepping stone in the past 5 years' work towards progressing the Irish research and innovation strategy, for example it is cited in the SSTI [ASC, 2006, Footnote 5, p. 23] (analysed later in this chapter).

Analysis: Evidence of Explicit Contextualisation

This report is quite repetitive and lacks academic depth in its arguments. It does gather some useful information to argue strongly for an increase in R&D funding from business and from the government to the national and EU agreed target of 3% of GDP by 2010.

Unusually for such a report the citation and referencing is not extensive. Only ten references are listed, with only one academic study included.

- European Commission, (2003) *State Aid Scoreboard — Spring 2003 Update* Brussels: COM(2003)225 final
- European Commission, (2003) *More Research for Europe* Brussels, 2003
- Forfás & Expert Group on Future Skills Needs, (2004) (forthcoming) *Model to Predict the Supply and Demand for Researchers and Research Personnel in Line with Ireland's Strategy for Contributing to the European Research Area 3% Initiative* Dublin: McIver Consulting
- Forfás, (2003) *Business Expenditure on Research and Development (BERD), 2001* Dublin: Forfás
- Forfás, (2003) *State Expenditure on Science & Technology, 2001 : Vol. Two – The Research and Development Element of the Science and Technology Budget* Dublin: Forfás
- Forfás, (2003) *ERA 3% Initiative – Review of Industry Potential to Increase R&D to 2010* PA Consulting Group Report to Forfás
- Forfás, (2003) *Public Procurement for Increased Innovation* Jacobs & Associates Report to Forfás
- Higher Education Authority, (2003) *The Programme for Research in Third Level Institutions (PRTLI) : Transforming the Irish Research Landscape* Dublin: HEA
- Irish Council for Science, Technology & Innovation, (1999) *Technology Foresight* Dublin: ICSTI

- Kearns, A. & Ruane, F., (2001) *The Tangible Contribution of R&D-spending Foreign-Owned Plants to a Host Region; a Plant Level Study of the Irish Manufacturing Sector (1980-1996)*

See [Forfás, 2004, p. 34] for this list of references in the report.

Thus, ironically, despite the very explicit focus on research funding, there is no discussion of the model of research and innovation used to justify such investment. Instead we have to look at more implicit references, in the next subsection, to tease out where this report is situated with respect to the theoretical models discussed.

Analysis: Evidence of Implicit Contextualisation

There is a definite implicit assumption that increasing R&D expenditure is a good thing. The general tone places an emphasis on the assumed economic impact of such investment.

> "Sustained investment in R&D is an essential foundation to maintain the competitiveness of the enterprise base and to develop Ireland as a knowledge based society, so as to increase productivity growth, provide a source of opportunity in new growth areas and to develop a basis for creating knowledge driven competitive advantage across all sectors of the economy. It will benefit society by informing public policy and decision making across all sectors such as health and the environment."
> [Forfás, 2004, p. 2]

Unfortunately, for the purposes of this thesis there is little evidence to support a view that the report uses a linear model of research and innovation, or a more complex model such as a generic systems approach. One can conclude that there is no evidence at all to assume that either of the two more specific models (i.e. the Triple Helix and the Mode-2 theses) have had any influence on this report. This is quite surprising; some justification for the need to invest in research that went deeper than the high level clichés provided in the report would have been expected. The counter argument is that the remit of the report was narrow: to plan for investment in research, not to justify it. The Enterprise Strategy Group also published a much more extensive report, ESG [2004]

Analysis: Summary

There is no explicit reference to a model of research and innovation being used in this *Action Plan for Promoting Investment in R&D to 2010*. Perhaps the justification is that it is a pragmatic report based on metrics, rather than a higher level

discussion. Instead the statements that are made serve more as platitudes (c.f. the previous section for a sample quotation from the document) about "knowledge based society". It is a disappointment that a document produced by Forfás after the previous work in this area is so weak in its theoretical foundations.

7.2.5 Enterprise Strategy Group 2004: Ahead of the Curve: Ireland's Place in the Global Economy

Summary of Document

This document is a Report to the Minister for Enterprise, Trade and Employment, Mary Harney in July 2004. It was produced by the Enterprise Strategy Group (ESG). It analyses the model for enterprise development in Ireland. Thus, research and innovation are important, but the scope is wider, covering the whole Irish economy rather than just the need for R&D. This report is in the tradition of the Culliton Report [Culliton, 1992], over 10 years earlier. The overall argument is a dual one of increasing Ireland's performance in R&D (both indigenous industries and in foreign direct investment subsidiaries) and in sales and marketing. Within this it is predicted that the service sector will grow to bring Ireland more in line with developed economies in Europe and North America. The main strategic direction for development emphasised is a shift from a manufacturing towards a knowledge-based economy. The critical aspects of this for research and innovation are (i) a dual role of producing good quality graduates to work in suitable industries, and (ii) the need to integrate innovation into the R&D process allowing technology-driven innovation.

Summary of Document Significance

This document's main significance was in terms of its recommendations of the organisation of state agencies involved in supporting enterprise.

Analysis: Evidence of Explicit Contextualisation

Although the report claims to have "examined enterprise development models from other economies" [ESG, 2004, Letter in Preface, p. iii] there is little explicit citation of formal models of innovation, or of models of research and innovation. Notably absent are the explicit references to National Systems of Innovation that dominated such reports in the 1990s.

> "The challenge is now to embrace the full spectrum of business capabilities within the enterprise model. While we have strengths in production, this alone will not confer competitive advantage. In fact,

> unless our production strengths are complemented by knowledge and expertise in other areas, we are likely to lose significant parts of our existing enterprise base to lower-cost economies. The new enterprise model has two facets:
>
> - It will be *market-led*: Enterprises in Ireland must develop strong relationships with customers and deep knowledge of the markets in which they operate, so that they can anticipate their needs and deliver solutions
> - It will be *knowledge-based*: Whereas in the past, products manufactured in Ireland were designed elsewhere, in the future, more of the ideas, the designs and the technology must originate here. Companies in Ireland will have to innovate and gain leadership positions in their target markets."
>
> [ESG, 2004, 2.10.2 p. 36]

So there is use of generalised terms such as "knowledge-based" without any detailed analysis of how this might be defined. This paragraph represents the highest level of detail at which the new enterprise model is discussed.

There is one slightly cryptic citation of a source that may discuss innovation systems: "Romanainen, Jari; Analysis of the Irish Innovation System 2004, unpublished." [ESG, 2004, Footnote 93 p. 66] cited to support the statement "Although there is a wide range of existing supports available today, their value is not being fully realised because of a low level of cohesion or strategic focus" [ESG, 2004, 4.2.2 p. 66] but that does not imply any acceptance of a National Systems of Innovation approach in the report itself. Thus there is no explicit reference to any of the four models: linear research and innovation (with basic and applied research), National Systems of Innovation, Triple Helix model or Mode-2 knowledge production.

Analysis: Evidence of Implicit Contextualisation

If one analyses the implicit use of models of research and innovation in this report the dominant justification for investment in research is actually to produce qualified graduates, with some acknowledgment that a degree of integration between knowledge production and exploitation is required:

> "SFI Ireland has already increased investment in R&D to improve the national capability and capacity for innovation. By 2015 we will need to have developed a knowledge and skill base that is extremely attractive to and valued by indigenous and foreign-owned firms.

> The research talent fostered by PRTLI, IRCSET and others will be a national competitive strength. It is important, however, that the knowledge and skills arising from these programmes be both exploitable and optimally exploited in Ireland. This will require focusing the research activities, developing capacity and capability within enterprise to commercialise the intellectual property arising from research and employing people with research skills."
> [ESG, 2004, 3.2.2 p. 51]

The way basic research and applied research are discussed implies that there may be an implicit acceptance of a linear model of research and innovation:

> "The primary benefit of investment in excellent basic research is the supply of people at PhD level. These advanced skills are of particular importance not only for the creation of new knowledge in Ireland, but also to ensure the scientific capacity to absorb new knowledge developed elsewhere. The focus of these programmes should be kept under review to ensure that they address changing needs.
>
> In order to fully realise the economic benefit of this investment in basic research, it must be complemented by focused, market-led applied research that addresses the specific needs of enterprise."
> [ESG, 2004, 4.2.1 p. 65]

The term "National Innovation System" is used once or twice (e.g. [ESG, 2004, 4.2.3 p. 70]) to denote "all the payers", but it is not used structurally to support an argument for a model of research and innovation.

There is little evidence of explicit or implicit reference to any of the four models.

In fact the dominant theme is an implicit linear model of basic research, applied research, and exploitation with little attempt to justify the rationale for investment in R&D. It is almost as if a theoretical understanding of the issues has regressed from the 1990s to 2000s.

However, the report does acknowledge the differences between technological innovation and non-technological innovation (the latter not necessarily linked to R&D, or at least not to basic research).

> "The ability of firms to develop products and services that address real market needs and can be sold at a profit depends increasingly on innovation. Innovation can take many forms, and can be applied to any part of the business. It may involve the development and application of technology (technological innovation), or it may involve other

kinds of knowledge and expertise, such as design, business process re-engineering, brand management, and marketing (non-technological innovation). Technological innovation depends on R&D, and on scientific and technological know-how. From a low starting point, Ireland has taken a number of significant steps to recognise the importance of R&D, including:

- Allocating €2.5 billion in the National Development Plan (2000-2006) to R&D and innovation
- Establishing Science Foundation Ireland (SFI) and the Programme for Research in Third Level Institutions (PRTLI)
- Plans to introduce an R&D tax credit scheme for companies in 2004.

However, despite these steps, much remains to be done to raise Ireland's R&D performance to a level comparable with other developed economies."
[ESG, 2004]

The report can also be credited with defining SFI and PRTLI as basic research investments (despite the commercialisation rhetoric around the SFI programmes) and argues strongly for increased applied research funding to even out the perceived imbalance in funding. It does not acknowledge the fluid nature of the basic/applied boundary, or how the same programme of activity could be justified as either basic or applied depending on the motivation of the funding agency (and the researchers response to those motivations).

Given the emphasis on basic and applied research, there is some evidence for an implicit linear model.

Analysis: Summary

This document represents the start of a trend for documents from the mid-2000s in as much as it mixes high level claims about the need for investment in R&D with little discussion of the theoretical models of research or innovation to justify such investment.

7.2.6 OECD 2004: OECD Review of Higher Education in Ireland

Summary of Document

In 2004 the Department of Education and Science invited the OECD to conduct a review of the Irish higher education system. The terms of reference covered the role of higher education, its strategic management and structure, teaching and

learning, research and development, investment and financing and international competitiveness. Two items in the terms of reference are worth quoting for the purposes of this thesis. Firstly the Knowledge Society is mentioned:

> "[. . .] demands associated with the knowledge society, lifelong learning, globalisation, meeting the needs of national and regional economies and of local communities, together with contributing to social cohesion and equity [. . .]"
> [OECD, 2004, p. 68]

and secondly the full text of the research and development paragraph:

> "**Research and Development:** Given the increasing importance of research, development and innovation for the knowledge society, examine how research and development in the higher education sector can best be supported and further developed to highest international standards and the outcomes of this knowledge be best applied in support of social, cultural and economic progress having regard to the integral connection between research and teaching and the development of an appropriate balance between these in institutions. "
> [OECD, 2004, p. 69]

The report itself addresses these terms of reference and highlights a series of recommendations that prioritised those relating to the binary structure of higher education in Ireland:

> "1. That the differentiation of mission between the university and the institute of technology sectors is preserved and that for the foreseeable future there be no further institutional transfers into the university sector;
> 2. That steps be taken to coordinate better the development of the tertiary education system by bringing the universities and the institutes under a new common Authority, the Tertiary Education Authority, but that machinery be established within the Authority to prevent mission drift;
> 3. That in transferring the institutes of technology to the new Authority the managerial controls on their freedom to manage themselves to meet institutional objectives be reviewed with a view drastically to lightening the load of external regulation; "
> [OECD, 2004, p. 63]

Many of the recommendations relate directly to research and innovation and funding of research:

"4. That greater collaboration between institutions be encouraged and incentivised through funding mechanisms in research, first degree and postgraduate degree work and in widening access and lifelong learning;
18. That universities review their human resource strategies with a view towards making the probation period longer and the granting of tenure more rigorous and to providing promotion routes to personal chairs as a reward for exceptional research performance or leadership;
27. That public investment in research and R&D needs to be further increased if the requirements of the Lisbon declaration for 2010 are to be met;
28. That the institutes of technology should continue to concentrate on applied research and that underpinning research resources should be the subject of specific investment by Enterprise Ireland, and not by the new Tertiary Education Authority, in targeted areas against clear national or regional economic priorities;
29. That resources for research and for research infrastructure including capital resources be better coordinated through closer links between the new Tertiary Education Authority and an expanded SFI (see below) and with universities being funded on the basis that they are required to accept responsibility for major building refurbishment or building replacement within the recurrent resources available to them;
30. That consideration should be undertaken now in respect to the future of PRTLI;
31. That steps be taken radically to expand the numbers of doctoral students in universities with the intention to more than double them by 2010;
32. That degree awarding powers for doctoral awards be concentrated in universities and that, except in the case of DIT, where such powers have been granted to institutes of technology by HETAC they should be rescinded;
33. That SFI be confirmed as the national agency for the funding of basic research and publicly funded R&D in higher education and that its powers and responsibilities be extended as described in paragraph 70 and that its board structure be amended to reflect its new role;
34. That the responsibilities and programmes of the Irish Councils for the Humanities and Social Science and for Science, Engineering and Technology should be subsumed under an expanded SFI;
35. That the Government appoint a Chief Scientific Adviser reporting

> to the Tanaiste and Minister for Enterprise Trade and Employment who would inter alia be responsible for the coordination of civil science and in particular coordinating the research investment conducted by other departments with that of the expanded SFI and the new Tertiary Education Authority.
> 36. That a Committee for Research Policy reporting to the Cabinet be formed which would develop and oversee a national strategy for research, R&D and innovation;
> 37. That all HEIs should have business incubator units or other facilities to encourage the exploitation of research through spin out companies; every effort should be made to involve private sector finance in such ventures;
> 38. That the new TEA should fund an expansion of professional research exploitation services in all HEIs and ensure that HEIs are accountable for such activity;
> 41. There should be a National Council for Tertiary Education, Research and Innovation to be chaired by the Taoiseach, which would bring together the relevant Government Departments with an interest or involvement in tertiary education to determine a rolling national strategic agenda for tertiary education and its relation to innovation, skilled labour force and the economy (see Figure 2);"
> [OECD, 2004, p. 63–66]

Thus the review recommends merging the management of higher education across the binary divide, but keeping the separate ethos that the binary divide represents: universities and institutes of technology.

Summary of Document Significance

The government accepted many of the recommendations, but avoided ones that might have proven too confrontational. Rather than establish a new Tertiary Education Authority, the IoT sector was moved to come under the auspices of the HEA in 2007.

Analysis: Evidence of Explicit Contextualisation

The one model that is explicitly mentioned is 'Mode-2' (just once as an aside) but Gibbons is cited:

> "We have recommended above that Enterprise Ireland should be encouraged to give targeted research infrastructure support to the institutes. But we would not wish to see lines being drawn too narrowly

> between the universities' and the institutes' contribution to innovation; modern (so-called 'Mode 2' related) research is as likely to spark off new exploitation ideas from commercial partnerships or direct from up stream basic research as it is from more downstream applied research (Gibbons et al 1994). We note that all the institutes have business incubator centres and we would encourage similar developments in the university sector."
> [OECD, 2004, 71 p. 34]

Ironically, this is used as a justification for universities to have access to the Enterprise Ireland innovation funding, whilst elsewhere the report argues against the institutes of technology being allowed access to the university-targetted funding. Arguably a deeper understanding of Mode-2 would favour allowing both, as the converse is equally possible: i.e. new basic research ideas flowing from a commercially targetted activity.

There is little evidence for explicit reference to the linear model itself. The term 'innovation society' is very dominant but there is no mention of 'innovation systems', or the primary authors associated with this approach. There is no mention of the Triple Helix.

Thus this report does not dwell in any detail on, and provides little explicit contextual reference, for its own view of research and innovation, despite making a large number of recommendations in this domain. The term 'model' is used extensively, but in the context of models for funding, or for resource allocation rather than for theoretical models justifying a particular decision.

Analysis: Evidence of Implicit Contextualisation

There is some evidence of an implicit linear model of basic research leading to applied research leading to exploitation and commercialisation, but close reading suggests that this is more of an emphasis on the necessity to build a critical mass of capability, and thus could also be categorised as a systems of innovation approach (though as noted above this does not appear explicitly). For example both readings are possible for paragraph 66 of the report (quoted here in full):

> "Developing a research infrastructure to sustain a research intensive environment goes beyond the provision of appropriate capital facilities, however, and includes equipment, technician, library and IT support and the provision of appropriate career paths and remuneration packages for research staff so that expertise can be built up in research teams that is sustainable and where teams do not break up, if there is a temporary hold up in grant moneys or specialist staff leave.

> We are strongly supportive in this respect of Professor Downey's Report Creating Ireland's Innovation Society: The Next Strategic Step (2003). Again, if basic research provides the feedstock necessary to generate applications and innovation universities need to have built into their resources an element that can be allocated differentially and on a selective basis (see paragraph 49 above) to those areas of the institution that are research active (so that some departments may have considerably more favourable staff student ratios than others). Unless a university is able to fund academic departments so that they can pump prime new young lecturers to enable them to move into research immediately on appointment in a competitive research funding market it will be difficult for such staff to get started in research and may waste their potential. A university also needs to be funded so that it can encourage research on a broader basis than merely in those areas selected by national research bodies. A 'dual funding' system both offers the prospect of bottom up innovation and provides 'floor funding' to maintain an institutional research infrastructure. Ireland will need to translate its investment in niche research areas in universities into a Broader & Deeper research culture before one or more of those universities can be classed as a 'world class' research university. "
> [OECD, 2004, 66 p. 36]

It is hard to discern a dominant implicit model of research and innovation from the report. Looking in detail at Chapter VII *Research, R&D and Innovation* [OECD, 2004, pp. 34–42] one can perhaps discern a latent linear model:

> "[. . .] a continuous investment in generic, or basic, research to sustain the flow of new research ideas, some of which, but not all, will lead to strategic 'downstream' R&D;"
> [OECD, 2004, 63 p. 34]

Analysis: Summary

This document does not link explicitly to any model for research or innovation. The primary thrust of the analysis was not to focus on research and development in universities and institutes of technology, so this is not necessarily a major flaw. The report does make some direct observations and recommendations on how to operate the system of research funding.

7.2.7 ACSTI 2006: Strategy for Science Technology and Innovation 2006-2013

Summary of Document

This report documented the agreed collaboration between the government departments responsible for Science Technology and Innovation in Ireland. The central importance of this is underscored by the fact that the *Foreword* is written by An Taoiseach Bertie Ahern, rather than one of his ministers. The central importance of the Department of Enterprise, Trade & Employment is clear from the introduction by Minister Micheál Martin.

Chapter One *Vision and Challenge* quotes the National R&D Action Plan, c.f. [Forfás, 2004], and this quotation is reiterated at the start of the *Executive Summary* quoted here:

> "Ireland by 2013 will be internationally renowned for the excellence of its research, and will be to the forefront in generating and using new knowledge for economic and social progress, within an innovation driven culture.'
>
> The development of the knowledge economy is one of the key challenges and opportunities facing Ireland. The factors which contributed to our economic success to date will not be sufficient to achieve this vision. Competition is creating pressure for improvements in efficiency, quality and productivity and a growing need to innovate. These pressures are only going to increase. They are generating the need to take courageous forward looking steps that will achieve real strategic change, show tangible medium term results and shape the future.
>
> There are very real challenges ahead. Science, Technology and Innovation (STI) in Ireland is still relatively underdeveloped. We now need to take a leap forward and move Ireland to an acknowledged leader in this field by means of this strategy. Success will be marked by increased participation in the sciences, increased numbers of people with advanced qualifications, enhanced contribution by research to economic and social development, transformational change in the quality and quantity of research, increased output of economically relevant knowledge, increased trans-national research activity, an international profile for Ireland and greater coherence and exploitation of synergies nationally and internationally. In summary, the strategy aims to deliver world class people and enterprises with the drive to succeed and the resources to do so."
> [ASC, 2006, p. 8]

Thus the tone is set for a high level policy statement emphasising the importance of STI in the context of a knowledge economy, with a nod towards social progress. This is a language dominated by the Lisbon Agenda that is referenced.

> "The "Lisbon" agenda is aimed at making Europe more competitive and innovative on the world stage. As part of that process the Barcelona European Council concluded that Europe as a whole should aim to reach a target of spending 3% of GDP on R&D by 2010, with two thirds of that spend to come from industry. Some Member States such as Finland and Sweden are above that target, while many, including Ireland (at 1.6%) are substantially below it. The National R&D Action Plan5 proposed that Ireland should aim to reach 2.5% of GNP by 2010, with two-thirds of the increase coming from enterprise. Perhaps more crucially, the Action Plan represented the beginning of a more structured approach to building Ireland's National System of Innovation, which this strategy aims to fully realise."
> [ASC, 2006, p. 23]

The document contains an interesting short history of the development of this policy in Ireland that is worth quoting as it gives an insight into the formal view of policy development in this area:

> "Ireland began to consider science policy during the 1970s through the work of the National Science Council and, subsequently, the National Board for Science and Technology. These efforts had a broad purview at the policy level, encompassing areas such as energy and the marine, as well as policy on technological innovation exemplified by the formation of Ireland's first biotechnology programme. However, during this period there was a significant disjunction between the effort put into policy analysis and the programmatic funding which might have flowed from that analysis. It was only with the advent of EU structural funding for S&T, beginning with the 1989–1993 CSF, that substantive resources became available for S&T. These manifested themselves through the Operational Programme for Industrial Development which funded the first S&T development programme devoted to enhancing industrial R&D, higher education/industry collaboration, university research infrastructure; and the Community Initiative STRIDE, which focused on R&D in Natural Resources, including marine, forestry and agriculture. These programmes, though relatively limited in resources, provided much of the base of in both policy thinking and programme design for current STI measures.

Perhaps the most notable feature was the almost total focus of activity in the period up to the start of the current National Development Plan, on applied research. It became apparent however through the national Technology Foresight exercise and analysis of international good practice, that attempts to build a system of applied research without a base of excellence in the underpinning sciences are not sustainable over time. In addition, as the Irish economy continued to develop and change, the human resources aspect of research policy came into sharper relief. There is a growing recognition that high level skills provide a key impetus to broad economic growth. Put simply, society, economies and individual firms benefit from having a good supply of scientifically and mathematically literate people, even though all such people may not be directly employed in the sciences. The commencement of the PRTLI initiative in 1998 represented a pioneering move towards solidifying this view.

...

A decisive shift in public policy and funding was initiated under the current National Development Plan (NDP), 2000–2006. The major initiatives involved the foundation and funding of Science Foundation Ireland (SFI) and the expansion of the HEA's Programme for Research in Third Level Institutions (PRTLI). Both of these initiatives have been the subject of review by panels of international experts, with very positive findings in regard to the rapid progress in building a base of world class research in Ireland. The graph below shows how Government investment in R&D has increased exponentially over the past decade.

These initiatives were complemented by increased resources for Marine, Agricultural and Health research, and the establishment of two Councils under the aegis of the Department of Education and Science: the Irish Council for Science, Engineering and Technology (IRCSET) and the Irish Research Council for Humanities and Social Sciences (IRCHSS), having responsibility for funding postgraduate research across a broad range of disciplines. Within the current NDP, STI has become a major strand of government policy, underpinned by significant resources. The importance of ensuring greater coherence in the development of the overall national system of innovation has been recognized by government. The Cabinet Sub Committee for STI and its supporting structures are now in place. "
[ASC, 2006, pp. 21–23]

Summary of Document Significance

This document is the best reference point for the agreed policy for STI. However, although it is heavy on statistics and detail, it is disappointingly light on the underlying philosophical understanding of the real nature of knowledge production and innovation. The assumption that it is valid to continue to fund the existing HEIs without an understanding of how the changing contextualisation within society and within industry misses the core problem of developing a successful integrated STI strategy. Thus, though it has many references to National System of Innovation, the report is directly in the mould of Vannevar Bush's *Science: The Endless Frontier* [Bush, 1945] — fund the universities and the industries will exploit what they need. This model does not fit the modern requirements of an SSTI policy, and is a step backwards from the much more articulate and academically grounded policy documents of the 1990s.

This report portrays a potential policy weakness where Ireland effectively outsources the intellectual basis for its policies to the OECD and the European Union, accepting the latest buzz words without critical engagement and analysis.

Analysis: Evidence of Explicit Contextualisation

There seems to be some explicit acceptance of the innovation systems model of research and innovation:

> "Within the current NDP, STI has become a major strand of government policy, underpinned by significant resources. The importance of ensuring greater coherence in the development of the overall national system of innovation has been recognized by government. The Cabinet Sub Committee for STI and its supporting structures are now in place. "
> [ASC, 2006, p. 23]

> "Thus the strategy aims to strengthen the National System of Innovation (NSI) across its many dimensions, particularly with regard to the systemic aspect: forging more effective linkages and interactions among the different parts of the system. These issues permeate the strategy. "
> [ASC, 2006, p. 23]

However, no reference is made to the authors of the key model(s), nor is there a discussion of the implications of the model(s). Thus, despite its primary focus on this area, the policy document seems to assume its own epistemological foundations, taking for granted that NSI is valid, and that the way to build it is

to invest in HEI, with an emphasis on producing PhD students, and delivering 'world class research.'

Analysis: Evidence of Implicit Contextualisation

The discussion of National Systems of Innovation has been placed in the explicit contextualisation section. However, it could equally validly be argued that it should be placed here, as it is in effect an implicit acceptance of a model that is not discussed or cited. It is, however, the sole model mentioned.

Perhaps more difficult to analyse is whether the use of the typical OECD Frascati terms, 'basic research', 'applied research' and 'pre-product development' imply any form of linear research and innovation model. It is likely that they do. In general, basic research is coupled with key university research centres with critical mass who achieve world class research. Applied research is coupled with institutes of technology who do regionally relevant applied research (by implication not world class). The health of the overall research system is measured by the number of PIs, the number of PhD level researchers, and then other research assistants and students and support staff [ASC, 2006, Table 2.3 p. 30]. The underlying assumption here seems to be that ideas flow linearly from these world class researchers into a system that then exploits them. This is not really the NSI model but a linear model.

Thus, the implicit model used to fund the HEI sector gives PIs the flexibility to categorise themselves as working in basic research and thus pass on responsibility for industrial linkages to others in the system, effectively de-contextualising them from industry and society, the opposite of the intended effect of the SSTI strategy. It also completely fails to acknowledge the much more complex realities of how new knowledge is created; it does not all flow from PhD level research.

Analysis: Summary

This document serves almost as the end piece for the analysis performed in this thesis. As an integrated national strategy for STI one might have expected some reference to the justifications for investment in research and innovation in terms of a theoretical model, but there is none. Unfortunately it seems that the policy documents have reverted to a metric-focused framework without a critical analysis of the justification for that framework.

7.3 Additional Texts—Funding Programme Reviews

7.3.1 HEA 2004: PRTLI Impact Assessment

Summary of Document

The HEA Programme for Research in Third Level Institutions (PRTLI) has been in operation in Ireland since 1998 with the first funding awarded in 1999 under Cycle 1. This review was conducted by a four person impact assessment committee, chaired by Professor Enric Banda [Banda, 2004]. The review was conducted after the PRTLI funding had been allocated for Cycle 3, in 2003, and it involved circa 100 international experts and academic peers engaging with 600 people in over 40 institutions over a period of 8 months reviewing the PRTLI impact from 1998–2003. The review process included site visits, desk reviews, bibliometric analysis, data and information collation, interviews and meetings.

The document was structured into these main sections:

1. Executive Summary (6 pages pp. 12–17)
2. Background information (2 pages pp. 20–21);
3. Aims and objectives of the PRTLI (2 pages pp. 24–25);
4. Terms of reference and procedures followed by the assessment (2 pages pp. 28–29);
5. Achievements and impacts of PRTLI programme to date (10 pages pp. 32–41);
6. Areas for further improvement (8 pages pp. 44–51);
7. Recommendations (4 pages pp. 54–57).

So the main focus, in terms of length of content, was on an attempt to introduce key metrics to evaluate the achievements to date, and on the discussion of the potential areas for improvement.

The report was published with a second volume that included reports submitted to the assessment committee (i) a report on the impact on teaching and learning by the Circa Group Europe; (ii) a report on the impact on institutional strategy and management by Indecon. Also in this volume was a more detailed presentation of the metrics and indicators used in the main volume, and some appendices, including a bibliometric analysis of each individual centres based on the centre's selection of ten publications.

The main tone of the document was very supportive of what it viewed as an innovative way of funding basic research in HEIs, with its focus on the development of institutional strategic planning, and on the promotion of links between research activities and teaching and learning activities in HEIs. The report is complementary about the individual achievements of the funded centres, and about the way that the funding promoted collaboration between institutions. The report concluded that PRTLI-funded research had a higher quality than the national averages in terms of bibliometric analysis, across all the funded disciples.

The report's major concern was the sustainability of PRTLI-funded centres. In this, it highlighted the issue of the flat rate 15% overhead rate meaning that the institutions in fact needed to support the centres from other cost centres. There was also a serious concern raised about the lack of maturity of intellectual property (IPR) and commercialisation policy in the centres and in the institutions, and about the potential issue of confusion of mission between the PRTLI and the SFI in Ireland's National System of Innovation in particular. Finally the report raised the issue of the conflict between the centres' recruitment policies and the academic departments' recruitment policies in the institutions, especially in top-level recruitment.

Summary of Document Significance

This review was seen very much as an interim review. Of the funding that had been awarded (€605M) less than half of it had been drawn down (€223M) at the time the review was conducted (figures cited as footnote [Banda, 2004, p. 28]).

The document provides clear evidence of the dramatic impact that the PRTLI had on research in Irish HEIs.

Analysis: Evidence of Explicit Contextualisation

The report specially uses the term 'Irish innovation system', although without citation of any of the key authors associated with this model. The discussion suggests a view that there is a more complex process than a linear research and innovation, but is unclear as to the extent to which this a reference to a model, or just a term used to describe agencies in Ireland:

> "[. . .] our discussions on the Irish innovation system have left us with a concern that the concept of a national innovation system, its distinctive operating characteristics in an Irish context, its constituent elements, their roles and interactions, appear not to be very clearly defined. We have to say that there seems to us to be little common agreement on how the national innovation system actually works in Ireland, or indeed of its requirements. Naturally, this lack of consensus

> increases the difficulties of an effective positioning of PRTLI with respect to its contribution to the innovation system. We believe that an examination of this issue, focusing particularly on the role and contribution of the research, education and training domain to the innovation system and the interlinked characteristics of these three elements within this domain, would be appropriate and timely."
> [Banda, 2004, p. 46]

To balance this, the report uses the term 'basic research' just three times, and all in support of the PRTLI as a funding scheme for basic research in Ireland. The complexity of the overlap with applied research and commercialisation is not fully explored, though some of the recommendations do highlight the assessment committee's view that more attention needs to be placed on the commercialisation processes.

Thus, the overall tone of the report leans away from a pure linear model, in its emphasis on the complexities of a National System of Innovation, and its belief that this has not been studied in sufficient detail in Ireland. Thus the investment in basic research is seen not as the direct cause of economic advantage through a linear exploitation process, but as a key part of a more complex innovation system.

Analysis: Evidence of Implicit Contextualisation

It is clear that the report does claim some potential for an economic contextualisation of research. Interestingly the first expected impact of "investment in domestic knowledge production would be an increase in the capacity of the knowledge absorption by society at large" [Banda, 2004, p. 20]. This is a mature view of the expected benefit of the investment, based purely on the idea of economic exploitation of the specific research programmes funded, but of a shift in the capacity of the national system to gather new information and innovate based on this. This is an implicit awareness of a more complex non-linear model.

This is the section on the impact of the PRTLI on innovation (with some specific institutional examples removed):

> "4.10 Innovation Impacts
> At this early stage, it is difficult to say what the commercial impacts of PRTLI research will be or what impacts the programme will have on Ireland's innovation system. We note the evidence of patenting activity by PRTLI researchers, with 60 or so patent applications to date and we are aware from our discussions with industrial representatives that the quality of PRTLI facilities is already attracting industrial interest. We can say also that we sensed little or no reticence in

> the institutions on this issue. On the contrary, institutional policies are generally supportive of technology transfer and commercialisation initiatives and a number of institutions have or are improving their support services and facilities in this area. ... Enterprise Ireland (EI) has recently introduced a number of initiatives to support commercialisation that will assist the third level sector and the Higher Education Authority has called for institutional strategies that will take specific account of commercialisation. We note however, the criticisms of our visiting experts on the awareness of IP issues at the level of the individual researchers and it may be that while the institutions and the Government agencies are making an effort, it is not adequately resourced, by comparison with the scale of activity in European institutions, for example, and its penetration is still relatively weak, especially at bench level. While the improvements mentioned above are encouraging, it seems that there is still much to be done."
> [Banda, 2004, p. 40]

Again the emphasis is on a high level understanding of the types of capability that are being developed, and an awareness that there are weakness at present.

The way the report addresses these issues underpins the view that the assumed model of research and innovation is non-linear.

Analysis: Summary

Although the report does not cite academic models of research and innovation directly, its use of the term 'Irish innovation system' to denote a complex non-linear system, which it feels is not properly understood in Ireland, leads to the conclusion that this report does accept a non-linear model of research and innovation.

It is within this wider model that it praises the PRTLI for its investment in basic research, as this helps build the overall absorption capacity of new knowledge in the country, which is an essential part of the innovation system.

7.3.2 SFI 2005: Science Foundation Ireland: The First Years 2001–2005

Summary of Document

This document was the result of Forfás commissioning an independent review of Science Foundation Ireland over its first four to five years. The internal evaluation panel appointed by the Minister for Enterprise, Trade and Employment comprised six people (including the chair): Professor Sir Richard Brook (Chairman), Dr. David Clarke, Professor David Finnegan, Dr. Wilhelm Krull, Professor Karin

Markides and Mr. Pat Toole. The panel started work in November 2004 and the report was published in October 2005.

The report documents the historical context for the establishment of the SFI, and its development since then. It also places this within the context of the funding of research in higher education, and of industrial development (with a subsection on Teagasc, the agriculture and food development agency).

The main body of the report provides an evaluation of the SFI, based on an evaluation methodology. The main method was direct discussion with representatives of the various bodies involved, including the SFI, management of the HEIs, the Principle Investigators (PIs) funded, the postdoctoral researchers employed, the research students in receipt of funding, and other key stakeholders. The panel also commissioned studies of (i) bibliometric data from the SFI PIs; (ii) the operation of the peer-review process; and (iii) industry views of the SFI.

In general the report is highly complimentary about the achievements of the SFI in such a short timeframe, i.e. managing a large budget and spending it effectively to create a culture of high quality academic research in ICT and biotechnology. The report included some minor criticisms suggesting there was room for improvement in terms of developing synergies with the HEA PRTLI and in terms of support structures for the commercialisation processes, potentially engaging with Enterprise Ireland to this end.

Summary of Document Significance

This was the first major review of the SFI. Its remit explicitly included the task of evaluating whether the SFI is on course: "because of the long-term nature of the research it is funding, it is very early to try to measure the impact it is having. Nevertheless, because of the importance of what the SFI is doing for Irish science and technology policy and for future economic development, it is desirable to make an in-depth assessment of progress to date with a view to making any necessary mid-course corrections." [Brook, 2005, p. 43]. Thus the remit included an examination of the appropriateness or efficacy of the SFI as well as its effectiveness and efficiency.

The report presents a very professional, though brief, overview of the context and history of the SFI. In general it endorses the existing policy. Two of recommendations for improvement can be seen as being about collaboration with other agencies: (i) potential synergies with the existing PRTLI funded research programmes suggesting collaboration with the HEA; and (ii) improvements in support mechanisms for commercialisation suggesting collaboration with Enterprise Ireland. It seems that these have led to serious attempts to improve the linkages, particularly with respect to Enterprise Ireland.

Analysis: Evidence of Explicit Contextualisation

This document makes clear reference to the history of the justification for public expenditure on basic research being linked to Vannevar Bush [Bush, 1945], whilst acknowledging a longer tradition of public support for research in Europe. The report also acknowledges that the simple basic/applied research distinction is not clear, and cites one of Calvert's papers [Calvert and Martin, 2001] that explored the use of the term 'basic research' by different people, and concluded that it was a very ambiguous term, but that that ambiguity might serve a function. Calvert's research was discussed in this thesis under the context for the research questions (c.f. Section 2.3).

> "In the years since Bush's report was published there has been extensive discussion among social scientists, economists and science policy experts concerning the role of research and its contribution to economic and social development. Governments are ultimately interested in funding basic research because of the benefits it is perceived to bring to society. In recent years there has been an acceptance of an increased importance for basic research through the emergence of certain technologies (such as biotechnology, genomics and nanotechnology) which require very basic research but can then quickly produce marketable products. Economic benefits include: increasing the stock of knowledge in strategic technologies; increasing the output of highly trained people who are at the forefront of developments in their scientific field and have established links to their counterparts around the world, enabling them to stay in touch with the latest advances; creating new instrumentation and methods; and creating spin-off companies.
>
> Recent studies have confirmed the convergence of basic and applied research, with basic research more and more having closer links to applicability[1]. Hence the economic argument for public support for research is becoming stronger. But, even more importantly, in the modern world of rapid change and increasing uncertainty countries invest in research to ensure they will have the skilled people who can handle the next period of change.
>
> 1. For example, Calvert & Martin: Changing Conceptions of Basic Research? SPRU (2001)."
>
> [Brook, 2005, p. 11]

There is one reference to National Systems of Innovation in the context of the HEA noting "the absence of any agreement as to how the national innovation

system works in Ireland" [Brook, 2005, p. 28]. Therefore this is not a citation of an academic model of research and innovation.

In sum these references could be read as a simple endorsement of the linear model, with an acknowledgment that the time taken to travel from one area on the line to another is reducing. Alternatively, they could be taken to acknowledge some form of non-linear system. Unfortunately the discussion in the report is too brief to give the full view of the panel, if indeed they had a consensus view. As none of the key non-linear models is explicitly referenced, and the key linear model is, the interpretation favoured here is that this report explicitly assumes a traditional linear model of research and innovation.

Analysis: Evidence of Implicit Contextualisation

There is considerable discussion of the SFI's stated mission "to undertake and support strategic research of world class status in key areas of scientific endeavour which would underpin economic development." [Brook, 2005, p. 6]. The discussion of how the research might underpin economic development is essentially an economic contextualisation of the research. Therefore implicit contextualisation is evident.

The question for analysis in this section is whether the discussion of this economic impact leads to potentially more nuanced models of research and innovation than the linear model that is explicitly cited. The analysis concludes that all of the discussion assumes that the good ideas originate in the SFI-funded basic research activities, and that the the problem is to create the appropriate technology transfer mechanisms to transfer this to industry, either directly through spin-out companies, potentially involving some of the researchers involved, or through licensing to external industry. The argument of this thesis is that this is essentially a traditional linear view.

Analysis: Summary

This is an excellent, succinct report. However, it is traditionally linear in its vision of how the research and innovation system works, both in its explicit references to Bush and to basic research, and in its implicit assumption of how the value of the research activities funded as basic research can be filtered through a linear system towards industry.

7.3.3 SFI 2008: Value for Money Review of Science Foundation Ireland

Summary of Document

This is an extensive report evaluating the value for money of the investment Ireland has made in Science Foundation Ireland [Indecon, 2008]. The report follows up on the previous Brook review [Brook, 2005]. The report was conducted by a consultancy company, Indecon, and drew on a panel of international advisors, some of whom had been involved in the earlier review. The report was submitted to the Office of Science, Technology and Innovation (OSTI) in the Department of Enterprise, Trade and Employment (DETE).

The overall structure is similar to the previous review, but with greater content. Thus the initial section detail the scope and methodology of the review. This is followed by a discussion of the national and international policy context. The SFI programmes are then evaluated using a series of different metrics: human capital measurements, research outputs, collaboration activity and commercialisation activity. Then the effectiveness and impact is examined, specifically for the research outputs using bibliometrics. Finally conclusions and recommendations are presented. The report includes extensive annexes.

Summary of Document Significance

This is a very comprehensive analysis of the metrics relating to the research funded by the SFI. It builds on the framework of analysis established in the Brook review [Brook, 2005], that had at its core a mature bibliometric analysis, and adds a set of detailed surveys of various stakeholder groups, including unsuccessful applicants for funding from the SFI.

The document clearly captures the impact that SFI funding has had in Ireland in terms of the people employed, including postgraduate researchers, other staff and students, and specifically in terms of the publication outputs of the researchers funded. In nearly all areas the productivity in terms of papers increased when SFI funding was won; in nearly all cases the SFI-funded groups perform better than those without SFI funding in terms of publications, and in nearly all cases the SFI related publications enjoy an early citation advantage.

> "Summary of Recommendations
> 1. SFI should continue to implement its core mission of funding research excellence in areas where Ireland can compete effectively on a global scale.
> 2. An increased focus on effective industry collaboration (see further below) and measures to enhance the commercialisation of research should form part of future management of the next phases of SFI

funding.
3. Increased focus is required to align collaborations by SFI-funded researchers with the requirements of industry based in Ireland.
4. Mechanisms to ensure that SFI funding maximises the leverage of EU and other international sources of funding for Irish research should be introduced.
5. The development agencies, including IDA Ireland and Enterprise Ireland, should intensify efforts to engage new and existing client companies with SFI-funded research teams/centres.
6. SFI should consider the merits of a centrally managed database of inputs and outputs relating to SFI funded projects, which would track a range of input, output and impact indicators.
7. A system of ex-post review, which would combine elements of the existing ex-ante peer review and interim review process but place greater emphasis on the assessment of economic impact and value for money, should be put in place for completed SFI-funded research.
8. Continued efforts are needed to ensure effective inter-agency interaction and co-ordination including, in particular, between SFI and HEA.
9. SFI should carry out regular, systematic bibliometric analysis of SFI-funded research outputs and publish the highlights of this analysis.
10. Measures to enhance the likelihood of top-ranking researchers remaining in Ireland should be given a high priority.
[Indecon, 2008, p. xv and p. 129]

The document comes back to the two key recommendations for integration with other agencies that the previous report raised in recommendations 5 and 8. The fact that the current SFI focus is very much on basic research and the quality thereof is acknowledged in recommendation 1, which argues that this should remain the case. This is balanced by an acknowledgement that the remit of the SFI includes a requirement to have an economic impact which leads to recommendations 2, 3 and 5 emphasising the need to build mechanisms to have such an economic impact for the research. In recommendation 4 there is a new emphasis on encouraging successful SFI funded researchers to leverage other forms of funding, including EU funding, that suggests some form of funding incentive be introduced.

Analysis: Evidence of Explicit Contextualisation

Although very similar to the previous review [Brook, 2005], this report does not have quite the same academic tone. Both are report style, rather than academic

discussion style, and so use footnotes as references to certain key documents (rather than a bibliography or a set of references). However in the earlier review there is an occasional footnote relating to the academic literature to reinforce a point; in the more recent review the few citations are directly to the Irish policy literature.

This means that there is little evidence of any explicit model for research and innovation. It could be argued that the review of the policy context is not a deep-structured one, but a highlighting of key policy documents and key decisions, rather than an exploration of the rationale for those documents or those decisions. Arguably this review is of similar style to the SSTI itself [ASC, 2006] where the metrics have become the drivers. The discussion about the history of the policy is dominated by graphs of HERD and BERD, and the EU Lisbon agenda discussion is about when the target of 3% GDP on R&D was introduced (in Barcelona in 2002).

So there is no evidence of explicit reference to a model of research and innovation.

There is a strong context of the need for SFI-funded research to have an economic impact, softened by the reminder that it is too early to judge this. For example "An important issue concerns the wider economic impacts of the investment in R&D activities supported by SFI programmes. Again, while we believe it is too early to deliver a definitive judgment on the extent of wider economic benefits, the limited available data on commercialisation activities suggests that some progress is evident (measured, for example, by reference to patent filings) but further evidence of impacts will be required in this area." [Indecon, 2008, p. 14].

There is explicit discussion of the researchers' and industry's view of whether the SFI should "focus on fundamental/basic research as opposed to applied research" [Indecon, 2008, p. 62]. Thus the analysis used may suggest a linear model. This discussion was based on the results of circulating a questionnaire to funded academics that included the following request (the same question was asked of companies and industry partners in a companion questionnaire): "Please indicate your views on the general concept of state investment in basic research as a way to drive industrial innovation and economic growth?" [Indecon, 2008, p. 233].

Thus there is an explicit economic context, but, other than an analysis of patent output, little engagement with the detail of how this might impact on or change the research activity itself. There is explicit reference to basic research as the correct focus for the SFI.

Analysis: Evidence of Implicit Contextualisation

With so much detailed information, but so little higher level discussion of its context, there is surprisingly little text to work with when looking for evidence of implicit contextualisation. There is a notable absence of description of the assumed research and innovation trajectory that could imply a linear or non-linear model. Thus one is left with the weak conclusion that there is an implicit linear model, based on the very simple assumed link from research to economic benefit, without any further detail of the process.

Analysis: Summary

Despite being a very detailed and significant report, this review does not deal with the intellectual issue of research and innovation, and how exactly the two might be be linked. There is some support for the conclusion that the report assumes a linear model of research and innovation.

7.4 Framing of Basic Research in Ireland

The analysis of the texts above is the core work by which the main research question can be addressed. However, it is also useful to look to some additional sources of public information to examine how the new modes of funding have been operated, and how their implementation could relate to the policy that established them.

This section complements the document analysis of the period 2001–2008 with an analysis of the emerging roles for the new funding instruments established as part of the STI policy that emerged in this period.

The two main instruments were:

1. the HEA PRTLI (a basic research funding scheme administered by the HEA, started in 1998);

2. the SFI (an organisation to administer a new funding scheme, established in 2000).

The creation of these two parallel mechanisms for funding at around the same time created a potential rivalry between the HEA (with its new PRTLI programme) and the SFI.

The SFI was established following the Technology Foresight exercise conducted under the auspices of Forfás that identified two main areas for strategic investment in research based on the nature of the industrial opportunities in those areas: biotechnology and ICT (Information Communications Technology). The

SFI was established under the Department of Enterprise Trade and Employment, alongside the IDA (aimed at attracting foreign direct investment) and Enterprise Ireland (aimed at supporting Irish indigenous industry). However, from the outset it focused on separating the basic research it funded from any direct requirement for exploitability, emphasising the *Frascati Manual* term 'oriented basic research' (c.f. 2.3.2). It is stated in the address given by John Travers at the opening of the first SFI call for proposals in July 2000 that this focus on basic research was an agreed long term policy decision:

> "The scientific research landscape in Ireland today is very different from what it was even 5 years ago and it continues to change rapidly. Investment in scientific research is increasing in many areas of social and economic activity. Surveys conducted by Forfás here in Ireland as part of an ongoing data-collection system across the European Union indicate, for example, that today, investment in research activities by the business sector is about 1.1% of GDP or about the average for all EU countries. This is a considerable improvement and represents a doubling of the level of business investment in research compared with the situation as recently as 1993. But it still remains below the norm for small, progressive EU economies like those of Denmark and Finland. In addition, the research undertaken by the business sector is narrowly based with some two-thirds accounted for by a small number of foreign-owned firms and with only 25 Irish-owned firms spending more than £1million per year on research.
>
> Naturally enough, fundamental or close-to-basic research does not feature greatly in the research investment of the business sector in Ireland. Such research is concentrated in the University sector and, to some extent is also undertaken or commissioned by research bodies such as the HRB, the Marine Institute and Teagasc. Until recently, fundamental research in the Universities was poorly funded and structured, apart from some "pockets" here and there, but this is now changing with the support of the highly progressive HEA funded PRTLI programme.
>
> When the Technology Foresight analysis, the progenitor of today's launch of a Call for Proposals, was initiated 2 years ago by the Irish Council for Science, Technology and Innovation (ICSTI), based here in Forfás, under a Task Force chaired by Brian Sweeney and under the leadership of ICSTI Chairman, Dr. Ed Walsh we knew that we were "pushing the boat" beyond what was previously attempted. The analyses undertaken identified quite clearly the research capability re-

quired to underpin the future development of the eight significant sectors of the economy covered by the analyses. In particular, it identified the need for significant investment in fundamental research to create the "seed-corn" for future social and economic development in Ireland - in addition to a more widely acknowledged need for investment in applied research.

The proposal to invest heavily in fundamental research in order to create the foundations to support future industrial development represents a significant evolution of industrial policy - a proposal which I am glad to say has been turned into a Government decision by the work of the Tánaiste and Minister for Enterprise, Trade & Employment, Ms Mary Harney TD and that of the Minister for Science, Technology & Commerce, Mr Noel Treacy TD. Such an evolution is highly consistent with the wider scope of industrial policy that has been put in place in Ireland over the past 10 years and that has worked so well in practice. International experience indicates clearly that investment in fundamental research, located about one-third of the way along the basic to applied research "zero to ten" number line, does generate, over time, opportunities for commercial exploitation of high-technology, high-productivity, high added-value projects in manufacturing industry and the services sector. In addition, it can also help to upgrade the whole third-level educational infrastructure in research, in teaching, in the quality of student intake and in the quality of the graduates and post-graduates which come through the system.

This message is being received loud and clear by our colleagues in IDA Ireland and in Enterprise Ireland from the many client firms that they deal with both in Ireland and around the world and by the Government in their many contacts with business firms both here and abroad. The result has been the allocation by the Government, on the proposal of Tánaiste Mary Harney and Minister Noel Treacy of over £500m to support investment in fundamental research in biotechnology and information and communications technology and in associated areas over the period 2000-2006. It is not every day that Ministers and the Government take a long-term 10-15 year time horizon specifically into account, when making decisions - as they have in this case. The vision and commitment involved is strongly acknowledged by the research community and by the industrial development agencies in Ireland.

The launch of the First Call for Proposals by Science Foundation Ireland here today is a first step by the Foundation in meeting the

> objectives mapped out for it by the Government. The focus of the Foundation, in the first instance, will be on fundamental research in the broad areas of biotechnology and information and communications technology. These are the areas which have underpinned the success of industrial development policies in Ireland for more than 20 years and which will continue to be strong drivers and sources of industrial growth and improved living standards for the foreseeable future.
>
> The objective of the Foundation is to help create in Ireland, as a fundamental part of industrial and science and technology policy, significant clusters of excellence in fundamental research - initially in biotechnology and information and communications technology and in related disciplines and which will be of scale and visibility that are widely acknowledged both here in Ireland and internationally."
> [Travers, 2000]

To that end SFI placed a priority on establishing clear processes to distinguish excellent scientific research proposals, led by excellent principal investigators. Their criteria are based on international academic peer review (reviewers are appointed to review the proposals, the key emphasis in evaluation is on high-impact journal publications, and so on). Thus the SFI in a sense competes with the HEA in terms of funding basic research in Ireland, but with a limited number of strategic domains.

The HEA was not entirely happy with this situation as is evidenced by some of the public comments in policy documents:

- "The principles and criteria in Chapter 3 help us to identify five major shortcomings: [...] A degree of confusion about the mission and activities of SFI and its future role in the funding of basic research"
  [HEA, 2002, 5.44 p. 87]

- "We are concerned that the technology transfer process aspects may be lost, unlike the UK, where Foresight is an important way of engaging industry with the research base. We acknowledge the steps recently taken by SFI through the Science, Engineering and Technology campus-industry partnerships initiative."
  [HEA, 2002, 5.61 p. 92]).

It seems that the HEA would rather reserve the basic research mantle for itself and push the SFI towards the industrial linkages implied by the Technology Foresight exercise. This is less an argument about differing models of the research and innovation process, than a friction between agencies with potentially overlapping

targets. However, despite the concerns articulated by the HEA, the SFI remained focused on promoting strategically-oriented basic research.

Arguably, positioning the SFI in basic research means that Ireland now has a surfeit of basic research funding, especially in biotechnology and ICT (funded by the HEA PRTLI and SFI), whereas applied research funding is more difficult to justify and acquire. Enterprise Ireland does have extensive funding, but nothing to date to match the large Centres for Science Engineering and Technology (CSETs) of the SFI, or the larger HEA PRTLI programmes (now called National Centres involving institutional collaboration), where one integrated programme may have a budget in excess of €20M for 5 years, plus additional capital expenditure from the HEA. In comparison the larger EI funding models have funds of around €400k for 24 months (for Commercialisation Fund Technology Development), or around €1.2M for 5 years for an ARE (Applied Research Enhancement centre in the institute of technology sector). Recently announced is a new scheme to combine IDA and Enterprise Ireland funding for Competence Centres that bridge the interests of an industry sector to academia, although 7 successful centres were announced in May 2009, none seem to to be explicitly linked to SFI CSETs; the Competence Centres may in practice have come too late to benefit from Ireland's positive economic climate, and may now struggle to get funding although initial feasibility funding awarded to these initial centres.

If the competences centres could be developed to be of equal status to the SFI and HEA-funded centres, this could introduce some balance into Ireland's National System of Innovation. However, it seems that this may not be able to happen, and that the current imbalance will continue, with more industry-linked activities being under-funded in comparison with high status pure academic centres.

SFI policy does of course emphasise the links to industry as being important, and it could be that as the metrics for evaluation of such activity progress, this potential imbalance could be addressed within the current instruments, and within the SFI. Indeed the launch of the SFI Strategic Research Cluster (SRC) award, in 2006, that promotes clusters of academic researchers with explicit industrial support, to compliment the SFI CSET award, could be said to address this. These SRCs have a budget of around €3M for 3 years, so are smaller in scale than CSETs but still significant. At the end of 2008 there were nine funded SFI Centres for Science, Engineering & Technology (CSETs) and 17 funded SFI Strategic Research Clusters (SRCs).

7.5 Findings: Documents 2001–2008 Summary

The dominant document discussed in this chapter is the formal articulation of a Strategy for Science, Technology and Innovation (SSTI) [ASC, 2006]. The set of documents that cluster around this reflect the operation of a policy where funding in HEI SET research has been channeled through the HEA PRTLI and SFI in particular. A number of other highly influential documents were produced in this period, starting with Skilbeck's report [Skilbeck, 2002], and including the OECD Review of Higher Education [OECD, 2004].

Reflecting this shift from documents aimed at justifying a change in funding priorities, to documents describing the operational details of the agreed new priorities, the overall evolution of the policy discussions on research funding of science, whether framed as SET, or now much more commonly as STI seems to have evolved from the 1990s where the documents presented a deep analysis of the core issues of how new knowledge was actually produced, and how this could be part of an innovation system to a discussion that accepts unquestioningly notions such as 'National Systems of Innovation' and focuses on metrics such as publications, citation counts and the numbers of PhD graduates. It seems a full understanding of the real nature of the complex interactions between research and innovation may have been lost, or at least de-emphasised, in this process.

So, whilst it is a laudable objective for the Irish government to continue to be committed to increasing its own direct investment in research as a percentage of GDP (HERD), and its stated objective to encourage Irish industry to increase its investment in R&D as a percentage of GDP (BERD), the policy documents seem to be naïve to the very real debates about the changing role of the academy as the centre for such knowledge production processes, and the potential new models of funding that may need to emerge to allow this to happen. Thus there is no discussion of any intermediate organisations (outside traditional, academic-discipline-structured universities) where the linkages between flexible, new, trans-disciplinary knowledge and its relevance to society and industry can be exploited more readily.

The funding programme review documents, assessing the HEA PRTLI programme [Banda, 2004] and the SFI programmes [Brook, 2005; Indecon, 2008], do indicate some self-reflection on the model of research and innovation that exists behind the metrics.

However, based on the analysis carried out in this thesis, it is the earlier Irish policy texts (from the mid-1990s) that show more advanced awareness of the complexities of the various models for research and innovation. Overall, it seems as if the language of the policy discussion has become operationalised as the programmes themselves were implemented from the late 1990s, where the terms are used without discussion and without citation, and are often used to justify

an approach which is at odds with the origins of those terms. Thus a National System of Innovation was originally a "system of systems" approach [DeLaurentis and Callaway, 2004] to understanding the very complex interactions between the agencies involved in research and innovation (typically a triple helix of state, HEIs and industry). Now the term is used to described a box diagram of these entities with a text that betrays a naïve linear view of these inter-relationships as if all knowledge flows from intelligent, academic professors, who have good ideas, to the less intelligent exploiters in industry, who merely operationalise these ideas.

Chapter 8

Synthesis and Conclusions

8.1 Introduction

The previous two chapters presented a detailed textual analysis of the key policy texts in Irish Science, Engineering and Technology research funding policy from mid-1995 to 2008. This analysis was carried out according to the methodology presented in Chapter 5. The overall contextual basis for this analysis was presented in the early chapters of the thesis, firstly from a structural perspective (Chapter 3), and secondly from a theoretical perspective (Chapter 4).

The basis of this exercise was to try to find answers to the research question articulated at the beginning of Chapter 2, which also presented a discussion of the terminology employed. This question was:

> *Is there evidence in the development of Irish research funding policy for a contextualisation of science, engineering and technology?*

which derived from two earlier formulations of the question:

> *Was Irish funding policy in the 1990s was based on an idealistic notion of basic research?*

and

> *Will future funding policy be based on a more pragmatic understanding of the value of applied research?*

The 'contextualisation' in the final formulation refers to an erosion of the view that Science, Engineering and Technology is unconnected, or apart from, society to one where it is intrinsically linked to society. Links from society to the Higher Education Institutions (HEIs), where publicly funded R&D is carried out, can be seen as having at least three main forms:

- the government departments and agencies that help fund it (here an economic context is paramount—justifying the funding with some return);
- the industrial context where the results may be applied (here also an economic context is paramount—linking academic research to industry);
- the general societal context where the outputs may help improve the standard of living for everyone (here a more general context dominates).

So the 'contextualisation' is framed by stakeholders holding the SET community to task as to how their activities link to societal issues outside of the academic endeavour itself.

The methodology uses the search for explicit and implicit reference to underlying models of research and innovation as a mechanism for understanding the policy documents' framework. The key issue addressed is the extent to which the policy documents embraced either (i) a traditional linear model, that allowed SET to operate relatively independently of external influence; or (ii) more recent models that try and capture the complex interactions between SET and the exploitation of its results through innovation, linking the knowledge production processes to a societal context. Arguably this shift can change the nature of SET itself, as argued by Gibbons et al. [1994].

This final chapter explores how the findings from the textual analysis of the policy documents relate to the core research question. It progresses the discussion of the research question, bringing in some additional evidence outside of the core texts analysed, and discusses potential further work. The first section draws together the findings in a consistent way, summarising the detailed documentary analysis of Chapters 6 and 7. Subsequent sections provide a more detailed high level discussion of the significance of these findings, and some proposals for further work.

8.2 Findings

This section presents specific comments that address the research questions outlined in Chapter 2. It is balanced by the following section that opens up this to a wider discussion of the significance of the results.

8.2.1 Findings: References to the Models

The first requirement for the findings is to summarise how the four models, three of which were explicitly non-linear in how they categorised R&D, and one of which was linear, were referenced by the set of policy documents analysed in detail in Chapters 6 and 7.

Document	Explicit Models	Implicit Models
Formation of Policy 1995–2000: Policy Texts		
[STIAC, 1995]	NSI	strong economic context
[DES, 1995]	none	inconclusive
[HEA, 1995]	none	discussion of PATs, economic context
[OST, 1996]	NSI	implicit linear
[CIRCA, 1996]	basic research	implicit linear
Formation of Policy 1995–2000: Funding Reviews		
[Forfás, 1998a]	explicit non-linear, NSI, Mode-2	all explicit
Implementation of Policy 2001–2008: Policy Texts		
[Skilbeck, 2002]	mentions Mode-2 and NSI	arguably implicit linear
[ICSTI, 2002]	explicit non-linear, NSI	all explicit
[HEA, 2002]	NSI	basic research autonomy —no context
[Forfás, 2004]	none	inconclusive
[ESG, 2004]	none	implicit linear
[OECD, 2004]	Mode-2 aside	implicit linear
[ASC, 2006]	none	implicit linear, economic context
Implementation of Policy 2001–2008: Funding Reviews		
[Banda, 2004]	NSI	non-linear, absorption capability
[Brook, 2005]	basic research	implicit linear, economic context
[Indecon, 2008]	basic research	implicit linear, economic context

Table 8.1: Summary of Analysis of Core Texts

Summary Table of References to the Models

This section will analyse the way the different models were referenced and used in the policy documents, discussing what significance this could have. Table 8.1 shows a summary of how the various models were referenced in the documents analysed.

Linear Model

This model is sometimes, incorrectly, attributed to Bush [Bush, 1945] where the argument is made for separating basic research from applied research, and allowing basic research to remain disconnected from society through its emphasis on pure research questions with no planned use. The argument is then that such research is best suited to state support in higher education institutes, and

that applied research is better funded by industry, and carried out in industrial laboratories. The implied model is that good ideas flow from the basic research, through the applied research and into commercialisation activities. This is taken as the dominant post-war view of supporting R&D in western economies.

In many ways this is the most difficult theory to measure. In the document analysis carried out does one count every reference to 'basic research' as an endorsement of the linear model? Clearly not. The approach taken in the analysis was to assume that if there was repeated reference to basic and applied research and an implied flow of ideas between them, and no other more complex model of research and innovation was mentioned or discussed, then it could be viewed that such references did imply a support for a linear model of innovation.

It is in the more recent research and innovation policy documents that this happens. Even in the very strategically important SSTI [ASC, 2006] it was concluded that it effectively posits a linear model of research and innovation.

The analysis suggests that, in many ways, the dominant model of research, that incorporated a definition of basic and applied research, articulated by Bush in 1945, has continued to dominate all policy discussion in Ireland. As will be discussed below, there are some exceptions to this general rule, but surprisingly, these occur more in the 1990s than in the more recent documents.

In theory perhaps this should not come as a surprise. This has been the dominant theory in use for many decades, and so has become a part of the culture of the politicians, the policy advisors and policy makers, and indeed of the scientists and engineers who have to write project proposals to win funding. Often it is the simple linear model that makes it into the big news stories: invest in research and the economy will prosper, invest in research and we will enable a knowledge-based economy.

Perhaps the problem is one of higher academic expectations of the document set than is really justified. To overstate the case in order to make the point — often these documents are composite documents developed by committees with the task of either composing a justification with very little new input, or if they have the time (such as the OECD Review) with so many inputs that it becomes hard to process. In such circumstances, expecting a clear authorial acknowledgment of a model for research and innovation in each potentially related policy document is unrealistic. In reality documents are fragmented, with different sections written by different authors, and potentially with different models and assumptions informing these sections. So there may be no single integrated view expounded, especially where agreement on such models was not the main purpose of the document.

National Systems of Innovation

A number of key authors have applied the systems approach to the analysis of innovation including Nelson [Nelson, 1993] and Lundvall [Lundvall, 1992]. The core argument is that innovation is non-linear, instead being driven by a set of complex interactions between institutions.

If there was any model that dominated the 1990s, in terms of explicit reference in policy documents with appropriate citations, it was the economically inspired National Systems of Innovation model. Surprisingly in the 2000s the meaning of the term seems to have been eroded. The term does appear, but without explanation or citation, and it is almost as if the meaning has been reduced to a descriptor for a number of boxes (e.g. state agencies, educational institutions and industry). The implication of the use of a systems approach to understanding a complex system seems to have been lost, and instead a simpler linear research and innovation model is used.

If Ireland was indeed focusing on the use of National Systems of Innovation, as the earlier policy documents of the 1990s do seem to indicate, then one would expect a shift towards a discussion of these issues of accurate measurement in the Irish policy documents. Instead we see the opposite; rather than a more detailed engagement with the underlying implications of the model, the reports move up to a level of abstraction where it becomes questionable whether they actually endorse an NSI model of innovation.

Mode-2 Science

This model was definitively described by Gibbons [Gibbons et al., 1994] and posits a fundamental shift in the nature of knowledge production and science, from a discipline-based system of peer review science (Mode-1) to a fluid, dynamic, trans-disciplinary Mode-2 science. Thus not only do good ideas no longer flow linearly from basic research, but the fundamental epistemological foundations of basic science itself are being eroded.

Similarly to the use of the NSI model, the Mode-2 model appears to have been referenced more in the 1990s than the 2000s. It is as if the more complex analysis of the research and innovation system has silently been dropped, without discussion, and this emphasis replaced with a focus on achieving funding targets for GERD.

In practice this model seems to hold most sway with policy makers au fait with the current trends in social science. Irish policy makers seem to have a more pragmatic economic focus and prefer the NSI model over Gibbons in an analysis of research and innovation.

Triple Helix

This model is described by Etzkowitz and Leydesdorff [Etzkowitz and Leydesdorff, 1997] as a complex interaction between industry, academia and government. The Triple Helix could be viewed as one instantiation of a more general NSI approach, and is non-linear by definition.

There is no evidence in the Irish policy literature that this theory has had any influence at all. Perhaps the explanation is simple, as it was formalised more recently than the other theories, i.e. in the late 1990s. Perhaps it simply missed the window when such things were discussed in Irish policy documents. The lack of a higher level meta-discussion of models for research and innovation means that there simply was no opportunity to address this newer model. It does however seem very well suited to use in the Irish context, capturing elements of key politicians' priorities.

8.2.2 Findings: Primary Research Question

The analysis shows that the earlier period (1995–2000) yields much greater evidence for an explicit contextualisation of SET in the policy documents, with detailed discussion in many of these documents of the various theoretical models for the research process itself, and the production of knowledge that results, and of the related innovation processes. Ironically, as the expenditure increased in the later period (2001–2008), there seems to be evidence for an operationalisation of the policy documents, so that they have become more focused on targets and metrics and less on a theoretical justification, and that as a result of this the explicit evidence for contextualisation is actually less in the more recent policy documents. This was not a result that had been anticipated at the outset of this thesis.

However there is still a very strong implicit assumption in the documents that the approach being taken will have a strong economic benefit for the country and not just a social and intellectual benefit. Thus investment in basic research is promoted through a range of justifications including primarily:

- the creation of a pool of well-qualified and scientifically literate PhD graduates requires a focus on basic research to train these students;
- the maintenance of Irish research at a world class level (as measured by publication metrics and citation metrics) requires a focus on basic research.

The problem is that the expression of these ideas in the more recent reports tends towards token reference to certain terms without demonstrating an understanding of the issues behind them, 'National Systems of Innovation' is the main example

of this, as it now often mentioned in documents, but without any indication of an understanding of the wider implications.

Therefore this thesis argues that the approach of analysing theoretical models in research policy does lead to a better understanding of the implications of the policy. The indication is that contextualisation was sought in earlier policy documents, but that delivery of this objective may be difficult with the operational implementation framework that has taken place, where powerful stakeholders, such as traditional university academic departments, have potentially steered the debate to suit their agenda of "basic research" without interference. This argument assumes that some form of contextualisation is desirable.

The later policy documents display an implicit expectation of contextualisation, including an assumption about relevance to society and amenability to industrial exploitation over some period of time, that is not matched by any form of explicit model as to how this might actually happen. Thus there seems to be a mismatch between this expectation and the traditional linear model that is assumed.

Interestingly there has been a debate in the United States recently about the potential loss of the leadership role the US has held in 'basic science' since the WWII, and the impact this may have on its economy. Some theorists argue that as long as the research carried out abroad (outside the US) is basic research, then the US will still be best placed to exploit this new knowledge. The argument here is based on the fact that the US has the best developed National System of Innovation (see [Zachary, 2008] that cites an article by Hill on the post-scientific society [Hill, 2007]).

So the succinct conclusion of the core research question is that there has been less contextualisation of SET, as expressed in policy documents, than one might expect, and that there was more in the policy formation period of 1995–2000 than in the policy implementation period of 2001–2008. So this means that much of the policy literature, and much of the custom and practice of how publicly funded SET research operates, can continue to live in a rarified world of "basic research", slight divorced from the requirements of society in general or of the economy. However, as discussed below, the change in economic conditions has brought this issue into focus, and one would expect more pressure for contextualisation in the coming years.

8.2.3 Findings: Ancillary Research Questions

As stated in Chapter 2 there are a number of ancillary research questions this thesis would like to explore, though it must remain focused on the primary question discussed in the previous section. Thus the claim was to discuss potential approaches and answers to the ancillary questions raised, but not to answer them

definitively.

> *Has Irish research funding in the 1990s produced any measurable economic benefit?*

The economic success that earned Ireland the moniker of the Celtic Tiger economy, pre-dated the large investment in research by the state. It would be very difficult to analyse the direct economic benefit of the increased investment in research since the late 1990s. However, according to its own justifications, much of this investment was in longer term research, with a timeframe of 10–15 years, and so may not yet be beginning to have an impact. Reviews of both the HEA PRTLI and of the SFI research programmes have indicated that it is too early to judge a direct economic impact of the research funding. More interesting is perhaps that none of the policy documents are yet asking this question. When it is asked in earnest, one might predict that it would take another period to implement mechanisms to perform any form of analysis on this basis, as that relevant statistics would need to be available for analysis. Of course it is notoriously difficult to do this, though the *Oslo Manual* [OECD/Eurostat, 2005] (a new initiative starting in the 1990s from the EU EuroStat and the OECD to capture innovation metrics in the same way that the *Frascati Manual* has done for general R&D metrics since the 1960s) may lead the way in creating operational indicators for innovation. Perhaps a positive move by Ireland upwards on these national indicators would suffice rather than direct proof of economic impact from specific programmes.

Arguably the key economic benefit to Ireland of research and development expenditure in HEIs to date has been the ability of the IDA to use this as a platform for securing the location of industrial research centres in foreign companies based in Ireland, by effectively allowing their Irish operations to "move up the food chain" in their corporate structures, or by attracting in new high-value investments.

> "Ireland's intellectual property laws provide companies with generous incentives to innovate. The Irish tax system offers huge support to turn brilliant ideas into the finished article. A highly competitive corporate tax rate of 12.5% is a major incentive. No tax is paid on earnings from intellectual property where the underlying R&D work was carried out in Ireland.
>
> Ireland recently introduced a new R&D Tax Credit, designed to encourage companies to undertake new and/or additional R&D activity in Ireland. It covers wages, related overheads, plant/ machinery, and buildings. Stamp duty on intellectual property rights has been abolished.

> The IMD World Competitiveness Yearbook 2007 ranks the investment incentives available in Ireland to foreign investors as among the best in the world. IDA Ireland is committed to supporting our clients to establish and grow R&D activities in Ireland."
> [IDA, 2009]

This is an evolution of the very successful earlier IDA strategy of attracting the basic manufacturing FDI to locate in Ireland from the 1960s to the 1990s. This is certainly reflected in the IDA's policy statements, but the analysis in this thesis does not directly show that this has indeed happened. One commonly cited example of a success for this IDA strategy (indeed it is the tag-line quotation on their website) [IDA, 2009], is the retention of a Bell Labs R&D centre in Ireland linked to SFI funding of a related CSET and to direct IDA financial support for the laboratory.

> *Do Irish policy makers and researchers agree on a definition of basic and applied research?*

With a few more nuanced exceptions, the main definitions of basic and applied research used in policy documents do seem to derive directly from the Frascati Manual. However, this question cannot really be answered without conducting direct research and by interviewing policy makers and researchers, as was done by Calvert in the UK and the US [Calvert, 2004].

The third and final question was not addressed directly in the research in this thesis:

> *Does the way the policies prioritise issues translate into proposal and project evaluation?*

Expecting even a partial answer to this from the type of research activity carried out in this thesis was perhaps too ambitious a goal. Instead it marks an interesting pointer towards one avenue for future research, i.e. whether there is a difference between how policies frame the issues (as this thesis directly addresses) and how the actual operation of research funding programmes, from a range of agencies, implement those policies (not addressed here). Access to the materials to conduct this type of study would present more issues than those posed by the analysis of public domain policy documents, and that accounts partially for the lack of focus on this interesting issue in this thesis.

8.3 Discussion

This chapter has argued that Irish policy documents are predominantly old fashioned and linear in how they treat R&D as a model. This means that they

generally eschew modern, non-linear theories of knowledge production and innovation in favour of an implicit linear model (using Frascati Manual terminology based on Vannevar Bush's formulation used as part of the process of establishing the NSF in the USA in the late 1940s).

An important implication of this is the implicit emphasis on a linear link from basic research (as funded by the HEA and the newly established IRCSET) and oriented basic research (as funded by the SFI), through applied research (as funded by Enterprise Ireland) and finally to technology transfer, diffusion and commercialisation (within the industrial sector). Thus, the assumption in Irish policy literature continues to be that ideas flow linearly through these stages.

This discussion first looks in detail at the agencies involved in Irish R&D funding and how the agencies have evolved, and how prominent their voice is in the national debate. Then it deals with the recent public reports, establishing the importance of innovation in an economy that has seen a dramatic decline in productivity. This leads onto the key recommendations that this thesis would make for future STI policy.

8.3.1 Discussion: Irish Research Funding Policy

Many Irish policy texts include a general appeal to the requirements of the Knowledge Society or the Knowledge Economy as a justification for why the large expenditure by the Irish government on the first phase of this linear process will have an economic benefit for Ireland in the longer term (10 years or more). In more recent documents the term 'Smart Economy' may have started to replace the 'Knowledge Society/Economy' as the primary high-level term. This is a recent occurrence, dating from discussions in 2008 leading up to the publication in December of the *Building Ireland's Smart Economy* report [Department of the Taoiseach, 2008]. There is one explicit reference to the Knowledge Society in this document, "We will publish a new Knowledge Society Strategy by mid-2009 with an action plan for the use of new high speed broadband networks to further our enterprise, educational and environmental objectives." [Department of the Taoiseach, 2008, p. 76], and this item is also included as part of the Executive Summary. There are a few explicit references to the Knowledge Economy, with reference to venture capital investment structures, intellectual property incentives, and the importance of the creative industries [Department of the Taoiseach, 2008, pp. 64, 73, 80]. It does not seem to be highly significant in terms of a semantic shift, but it is interesting that the policy now promotes an Irish-coined termed rather then the previous more global term, popular with the OECD.

The creation and subsequent positioning of Science Foundation Ireland is arguably the main factor in recent Irish research and innovation policy. SFI was established as result of the Technology Foresight exercise in the 1990s, an exer-

cise driven by an attempt to predict the key requirements of industry, and was created under the auspices of the Department of Enterprise, Trade and Employment. Despite this very applied, industry linked, focus of its creation when it was established the key appointees were from the US National Science Foundation, and they instituted a policy within the SFI of prioritising academic quality of research above all other metrics. What this did achieve was the creation of an independent research funding body, that awarded funds based on the scientific merit of the proposals, under the dynamic leadership of Dr William Harris. However, the result was that a large research funding mechanism that had been established with a clear remit to stimulate the economy, was being run more like a basic research funding agency. In more recent years, with the appointment of its second director Dr Frank Gannon, the SFI had made efforts to move closer to industry, and has required more industry engagement from its flagship CSETs, and has established a new programme SRCs (Strategic Research Clusters) that require more industry engagement. It has done this without losing its original strong emphasis on academic quality.

This thesis would argue that the SFI's delay in engagement in its intended industry remit, has delayed a real engagement in Ireland with the challenges of building a healthy integrated National System of Innovation through an disproportionate emphasis on basic research. The thesis would argue that it is in the area of applied research rather than basic research, especially programmes that explicitly link academia and industry, that one is more likely to see an examination of the more complex nature of the idea flows implied by the non-linear models of research and innovation. In academic domains where many advances are made in industry rather than in academia, these types of programmes may be the only ones that are appropriate. Arguably ICT is one of those domains. Thus one would predict that if the basic research focus that has taken place continues, it should be balanced by much more aggressive applied research programmes that give freedom to academics to link to industry, but without industry dictating the whole programme.

The Higher Education Authority (HEA), part of the Department of Education and Science (DES) in terms of reporting structures, tend to couch their literature, and their evaluations of proposals, in the general institutional policies for research and development in universities and institutes of technology. Indeed the HEA PRTLI programme is based on an institutional submission model, where the institution itself must prioritise its bids, and decide what to include in the integrated proposals. The advantage of this approach has been a gradual maturing of these research and development strategies in universities and institutes of technology, making the key decision makers in these institutions acutely aware of the importance of these strategies, given that they represent one of the main

mechanisms for capital investment in campus development. A negative view of this process is that these policies or strategies are effectively just more documents, and may not address the core complexities of analysis of each institution's contribution to a National System of Innovation. Indeed it sometimes seems that the most common metric one receives from universities asked to evaluate their strategic links is the number of MOUs (Memorandums of Understanding) they have signed with these partners. Certainly the HEA could do a lot more to evaluate its funded programmes on the basis of their research outputs, rather than just in terms of financial management and research student throughput. In this the HEA could learn a lot from how SFI operates its ongoing funding award evaluations.

In contrast Enterprise Ireland (EI), whose funded research programmes are much smaller in scale than the HEA PRTLI programmes or the SFI CSETs and SRCs (which all range from €5 Million to €20 Million per award), does have a very explicit remit to evaluate proposals, and running projects, in terms of their potential for economic impact. Indeed their evaluation processes often involve a parallel evaluation by academics of the research content, and by industrial analysts of the commercial prospects; both need to be satisfactory for the board to approve funding. If the policy is to shift towards giving the exploitation of R&D equal weight with academic criteria of excellence, then one need look no further than Enterprise Ireland (EI) for a set of evaluation techniques across the whole spectrum of research awards. EI generally has separate academic and commercial evaluations, and many types of funding require high scores in both to gain approval. Enterprise Ireland, has many other responsibilities other than R&D in HEIs. The main focus of Enterprise Ireland is to support indigenous Irish industry. The focus on funding for HEIs to link to industry is a secondary concern. Coupled with this Enterprise Ireland is not staffed by high profile academics with strong research track records of their own. This combination has allowed the SFI voice (that has been mainly a basic research voice as agued above) to dominate the national debate, without a balancing applied research voice, or a clear integrative voice arguing for how best to link the two. The result has been to see basic research as the main issue, and applied research and commercialisation as less important consequences of the prime focus, that will flow naturally in a linear fashion, once he primary focus is maintained correctly.

The potential is there on paper for an integrated Science Technology and Innovation strategy in Ireland. The Office of the Chief Scientific Advisor, and the Cabinet Committee on Science, Technology and Innovation, does link all of the relevant departments and state agencies. To date, however, this has not created a shared ethos based on a model of research and innovation accepted by all parties, and it has certainly not impacted on the separate views and ethos of

research. Perhaps the main issue, as discussed in detail in Chapter 7, is that the SSTI (Strategy for Science Technology and Innovation) [ASC, 2006] document was too low-level and metric-driven without a clear ethos and justification of its models, and that all these structures are designed to implement the SSTI. Perhaps another factor has been the delay caused by the resignation of the previous Chief Scientific Advisor, Dr Barry McSweeney, in November 2005, having been in the post for just over a year, and the subsequent appointment of a successor, Prof Patrick Cunningham, in December 2006. Arguably this created a temporary leadership vacuum for the whole STI process, and allowed the various agencies to stay within their own world views. It is hard to deduce this type of information form pure document analysis; it would require private interviews and raise issues of confidentiality and privacy.

Thus one could view the result of the Irish policy development, and funding developments, as the traditional, discipline-based university view of academia dominating the debate, and of basic research priorities dominating the debate, certainly when it came to actually funding the proposals. This framing of the debate did not allow for innovative newer models that might not fit the traditional academic domains so neatly. Thus Irish research funding policy has been strong on science but may weaker on innovation.

8.3.2 Discussion: Innovation During an Economic Crisis

Arguably the current government have attempted to address the imbalance between research and innovation in policy emphasis, in particular with recent publication of the *Innovation Task Force Report* [Irish Innovation Task Force, 2010].

Indeed aspects of the views expressed in this thesis, that are critical of the emphasis of Irish policy to date, were publicly expressed by Dr Chris Horn, an Irish computer science academic from Trinity College Dublin and a member of the Innovation Task Force. Dr Horn is also now the Chair of the governance board of the SFI-funded CSET (Centre for Science Engineering and Technology) CTVR (Centre for Telecommunications Value-Chain Research): [on his blog]

> "in my own view, the Irish state agencies — and in particular Science Foundation Ireland — have insufficiently focussed on the opportunity to translate world class research undertaken in Ireland into innovative products and services for the global market. In my view, Science Foundation Ireland is myopically focussed on Science: but what we also need — perhaps need even more — is a focus on Engineering. Ireland needs to take the most interesting scientific results globally available to engineer innovative, new products and services for the world market.

> I was surprised and concerned, for example, to learn that SFI reputedly believes that the work at REMEDI is overly focussed on commercial exploitation and industry linkage, rather than as SFI reputedly believes what is more nationally strategic basic research: this seems to me to in fact be the antithesis of what the small open Irish economy, with limited financial resources by global standards, actually needs. I am surprised and disappointed, that SFI does not have, and a senior executive has actually told me that it does not see the need for, a national showcase or centre for the outstanding scientific results which its sponsored researchers have already produced, and which are available for uptake by national and multi-national industry at large. [...] I am surprised and disappointed that SFI seems to think it can be just a shipyard launching ships, rather than an admiral not only building ships, but leading a complementary and mutually re-enforcing cohesive fleet to take on the world."
> [Horn, 2008]

Thus it seems the debate about the linkage between the new Irish basic research activity, funded by SFI and the HEA PRTLI programmes, and the economic exploitation of the research has now begun in earnest. The first concrete change since the publication of the Innovation Task Force Report was the cabinet reshuffle of March 2010. Here the Minister of Education and the Minister for Enterprise swapped portfolios, and the two departments were renamed: Enterprise Trade and Employment became Enterprise Trade and Innovation (DETI) ; Education and Science became Education and Skills. Perhaps most significantly for R&D policy, the HEA PRTLI programme was transferred from the Department of Education to Enterprise. This means that the new DETI has responsibility for al of the large research funding programmes in HEIs: PRTLI (basic research and capital investment), SFI (strategically oriented research), and Enterprise Ireland (commercially focused research and development). The research councils (IRCSET and IRCHSS) remain within the Department of Education.

Perhaps the problem with the execution of the STI policy in Ireland is that the primary responsibility for reporting on the effectiveness of each programme of investment in R&D rests with each separate agency providing the funding. There has been a process to try and align the agencies involved, including the SSTI itself, and the setup of the joint cabinet committee that enables of the oversight of STI policy, but the reality on the ground has been an autonomy for the agencies, each with their own focus. As argued above, the strongest voice that has emerged as been the SFI, and so the interests of the other agencies, and the interests of integration, have suffered.

However, the current climate is one of cuts, and this changes things. Perhaps

the most significant recent government report for this thesis, published since the cut off date of 2008, is the McCarthy Report, formally *Report of the Special Group on Public Service Numbers and Expenditure Programmes* but known colloquially in Ireland as "An Board Snip Nua" (mixing Irish and English–the new snip board) [McCarthy, 2009], recommending to the government how to reduce public sector spending across the board. Thus the risk is that the PRTLI will simply cease to exist, and SFI and Enterprise Ireland will have severe cuts in their research programme budgets, as the funding will not be available to sustain them at the levels seen from 2008–2009. Indeed the McCarthy Report recommended rationalisation in the HEI sector, and in parallel the government has established a process to report on how best to do this, this new report, the Hunt Report, has not yet been published, though aspects have been leaked.

So, the changed economic climate has meant that every aspect of public sector expenditure has been questioned. However, innovation spending, linked to job creation, is being put forward as one of the possible ways to stimulate economic recovery and growth. It is within this new context, where direct links of research spending to economic returns are paramount, that STI debate is currently taking place in Ireland.

8.3.3 Discussion: Recommendations

Irish research and innovation policy should engage in more research into the system of innovation itself. Indeed this seems to be good general advice for many countries, as clearly articulated by Arnold [Arnold, 2004]. It does not matter in this sense which non-linear model is preferred (NSI, Mode-2, Triple Helix or some alternative), but that some measurement of the complex networking effects created by the various actors needs to be in place, and some form of policy review process operating at the higher systems level is required, not just a review of projects and of individual agencies. These studies should also address the issues of how to best encourage the creation of deeper linkages in this complex system through strategic use of funding. Perhaps some of the studies should be outsourced, in part to other countries with expertise in this type of analysis, such as the Scandinavian countries.

Ireland should value, and fund, all parts of the NSI equally. The analysis of the artificial divide between basic and applied research in Section 2.3.1 presented Stokes' view of Pasteur's Quadrant [Stokes, 1997]. Having seen the dominance of the linear model, or no model, in the Irish policy literature, one could conclude that Ireland's current funding system encourages the continuation of this divide between basic (HEA and SFI) and applied (EI) research, with a lower status for the latter, that makes it difficult to create real strategic links between academia and industry. Changing the status of applied research to make it equal to basic

research, and preferably changing the overall definition so the distinction becomes less important, could help create a more innovative system where ideas could flow from different parts of our National System of Innovation, and find suitable funding support mechanisms. This means that this policy should both change to broaden and support a wider range of metrics as having equal value for existing research programmes and institutions. Part of this could mean building capacity in the Institute of Technology sector, who may be better placed to engage with industry. The specific support mechanisms for this sector (Strands I and III of the TSR) have been allowed to lapse, another demonstration of the non-parity of esteem for the different types of focus.

Irish STI policy should seriously consider whether it needs to encourage new forms of institution to be set up to bridge the academic/industrial divide, independent innovation institutes if you will. This was discussed briefly in Chapter 3, where it was noted that Ireland's NSI lacks such bridging institutions [Cogan, 2003, p. 37]. This argument will not find favour when the pressure is there for rationalisation, and a reduction in the number of HEIs themselves. However, the thesis would argue that if HEIs continue to dominate the landscape as they have done, the unbalanced emphasis on basic research will inevitably continue. The risk is that high profile academics, and PhD programmes, will thrive, and industry linkages will be nominal. Fundamental to this argument is the experience of our own research centre, the Telecommunications Software and Systems Group (TSSG), in Waterford Institute of Technology, comprising 140 researchers. This centre is unique in Irish academia in having a minority of traditional academics (only one third are faculty, students and post-doctoral researchers). Thus the majority have a strong industrial background, and are engaged in activities that bridge the gap between academia and industry. In general, when large research centres exist in HEIs, the balance is typically 90% academic, and other than the TSSG never with traditional academics in a minority. The continuation of funding mechanisms that promote such configurations will inevitably prioritise academic criteria, as such criteria will always be the most important to the majority of those making up such a centre. Only when one allows a more diverse and balanced membership, can one have a more balanced emphasis across the spectrum from basic research to commercialisation activities. Perhaps we should just acknowledge that directly inside a HEI is not the best places to do this, and that building these new bridging entities is necessary.

The most obvious place where a change is needed in the current policy is the SSTI. This needs to be revisited with a justification for the funding required being given and this being based on an explicit understanding of the model being used. Ideally the SSTI should engage with the academic theoretical literature, and to gather metrics that show a deeper understanding of the Irish NSI than simply the

publications, the citation counts, the number of PhD graduates, and the levels of funding. Another way of saying this is that the policy should respond to the economic crisis and make sure that it is directly relevant to the economy as best it can, and failing to engage with the non-linear models will continue to distance the policy from any potential economic or social impact. In this the Innovation Task Force Report [Irish Innovation Task Force, 2010], and the submissions made to it, provide some useful ideas.

8.4 Further Work

There are a number of ways in which the work presented in this thesis could be progressed. It seems that the analysis of public policy documents has highlighted some interesting tensions in the broad political consensus for investment in R&D in Ireland since the mid-1990s. Perhaps most importantly is the potential that the policies lack an understanding of the real complex nature of the link between R&D and innovation, despite the repeated linkage of these in terms of the justification for the investment, albeit over a medium to long term (often stated as 10 to 15 years).

8.4.1 Continuation of Approach with New Materials

As new materials are published they become open to analysis with the same framework as used in this thesis. Thus it might be interesting to keep abreast of how the central policy documents justify investment in R&D in HEIs, and how the principal research funding programmes, SFI and the HEA PRTLI, justify themselves in their review processes.

As a follow-up activity to the publication of *Building Ireland's Smart Economy* [Department of the Taoiseach, 2008] the Irish government has established an 'Innovation Taskforce' that is examining options to increase levels of innovation and the rates of commercialisation of research and development on a national basis, with a view to accelerating the growth of indigenous enterprise and to attracting new knowledge-intensive direct investment, building on the existing Government Strategy for Science, Technology and Innovation (SSTI) [ASC, 2006]. The Taskforce is chaired by Mr. Dermot McCarthy, Secretary General of the Department of the Taoiseach. Members of the Taskforce include representatives from the private sector, higher education and relevant government departments and agencies. The Taskforce has been asked to submit its report to Government within six months of its first meeting, which was held on 17th July 2009. As part of this process the Taskforce requested submissions (with a deadline in September 2009), and has subsequently published 101 of these submissions publicly [Irish

Innovation Taskforce, 2009]. These 101 public submissions to the Irish Innovation Taskforce would be obvious candidates for such an analysis, as this document set, perhaps for the first time, creates a single set of documents reflecting a wide subset of potential, interested parties at a single point in time. It should be noted that materials from this thesis helped inform the TSSG's submission to the Taskforce. Note that the Task Force Report was published in March 2010 [Irish Innovation Task Force, 2010].

8.4.2 Broadening the Methodological Approach

One form of methodological expansion would be to include other approaches to the textual analysis itself. This could use this thesis as a starting point to probe into the fragmented bricolage of the policy texts, deconstructing the texts themselves as artefacts. Such an analysis could lead to some interesting commentary on the modern Irish state.

There are limitations to a study based on an analysis of public documents. It would be possible to probe more deeply into the social process behind the creation of these documents by interviewing key participants, and by modeling in more detail the policy formation processes around the area of STI in Ireland. This would require a more detailed analysis of the potential, vested interests involved, and of how these may have influenced the evolution of the policy.

A third form of methodological expansion would be to include more international comparison as part of the analysis itself. This would require some form of attempt to create reference points between systems operating within different contexts.

The final expansion of methodology to be discussed here is the expansion of the area of study into the sociology of the agencies involved, and into how they operate the funding programmes. This could expose tensions between the public documentary priorities, that were amenable to the textual analysis performed in this thesis, and the potential, alternative, cultural priorities embedded in the people involved and the operational processes that they follow. Thus, for example, a policy document justifying the investment of research funding in a particular programme might emphasise the importance of industrial linkages, whereas the operation of that programme might not award any credit for this, and so actually prioritise more academic metrics.

8.4.3 Analysis of NSI

An obvious avenue for future work is to branch out into the measurement of the Irish National Systems of Innovation in a direct way, and then to use those measurements (especially if some of these could be made retrospectively) to analyse

how the implementation of the Irish STI policy has impacted on these metrics. The metrics currently emphasised in the SSTI [ASC, 2006, pp. 87–89] are:

- **People** PhD graduates;
- **Publications** Publications per million population;
- **Citations** ISI Citation Index rankings;
- **Internationalisation** Share of HERD funded externally from Ireland;
- **Support for Research Commercialisation** Technology transfer, patents, licence agreements, revenues from fees/royalties, health of spin-outs;
- **Enterprise R&D - Targets** Range of targets for investments in R&D activity by industry.

The Irish Venture Capital Association (IVCA) has published two annual reports on the Irish innovation system emphasising their contributions towards these government targets [IVCA, 2005, 2006]. It would be interesting to look at the more complex metrics that try to capture the complexities of interrelationships within an innovation system rather than focus on the easier-to-measure items listed here that do not directly gauge the health and complexity of the innovation system itself.

8.5 Summary

This thesis has analysed a substantial subset of Irish policy documents from 1996–2008 dealing with STI. It has analysed these documents using a framework based on a number of theoretical models of research and innovation. It has concluded that Irish policy documents were more theoretically nuanced in the 1990s, when the increased investment in R&D was initially being sought and justified. As the country moved towards a phase where this money was actually allocated, in the 2000s, the policy documents shifted mode to become more focused on comparatively more easily measured targets, and less on the complexity of the research and innovation process itself, and models to describe it. This is a weakness in Irish innovation policy.

However, the Irish policy is very much grounded in an economic language, with some allowance for a broader societal context, so it is clear that R&D is not seen as an end in itself, but as contextualised within an economic and industrial framework, and within a society that has needs that should be met. Given the early phase of the increased expenditure, it is difficult to analyse the extent to

which the investment has had any direct returns—and it is widely acknowledged to be a very difficult thing to measure.

Given the early prominence of the model of a National System of Innovation in the literature of the 1990s, one would have expected to see a discussion of metrics linked to this model. Instead the metrics proposed by the SSTI were focused on the overall outputs at various stages of the system (e.g. publications, citations, patents, scale of companies' investment in R&D), rather than on analysing the function of the system itself. One would expect over time that this imbalance might be redressed. In so doing it may be discovered that the emphasis on traditional definitions of basic research, and its focus on fundamental science coupled with a lack of focus on application (even in the agency established to fund the oriented basic research of the technology foresight areas of ICT and BioTech—Science Foundation Ireland) may lead to a system that places too great an emphasis on the basic research elements and not enough on the applied research elements for a healthy National System of Innovation.

One would also expect the development of a healthy public debate, documented in policy documents, about the most appropriate model of research and innovation for a country like Ireland to follow. This would require much more direct reference to academic theories, and potentially the development of implementation-driven metrics that link the health of the research part of the innovation process with the innovation part of the process, ultimately creating wealth and economic activity. Given that Ireland has agencies with the explicit remit of fostering the linkages between research and innovation in academia and industry, the country has the capability to develop its own models that are based on a small highly integrated economy with a well-educated workforce, and a strong presence of foreign direct investment (FDI) from multinational corporations. The problem could of course lie in this reliance on FDI, as it means that the industrial capability to exploit any innovative ideas lies mostly in foreign boardrooms, rather than in Ireland. However, given that open innovation, where even competitors share ideas with each other for potential mutual benefit, is becoming a dominant theme of modern research and innovation (c.f. Chesbrough [2003, 2006]), there should be a place for an Irish model of how to foster its National System of Innovation.

Ironically the debate in Ireland today, in 2008 and 2009, has been about trying to protect the continued investment in research and innovation, arguing that the process takes time and has long term rewards, in a climate where the national finances are under pressure from the collapse in tax revenue. This means that there is a danger that the process of investment in research and innovation will be curtailed before the policy and its process has had time to mature enough to justify what has been lost. The opportunity is that the engagement in this debate

could help everyone be more clear about what model of Research & Development is being promoted, and what consequences the promotion of such a model has.

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Appendix A

Notes on Thesis Formatting

A.1 Document Typesetting

This document has been prepared using the LaTeX typesetting system. The Mac OS X version of the TeX platform bundled with a set of useful tools as the `MacTeX-2008` release (c.f. `http://www.tug.org/mactex/`). The document was also processed on Linux Ubuntu, using `pdflatex` from the `http://www.tug.org/texlive/` package, to ensure cross-platform portability of the character encodings used (UTF-8). The bibliography and citation mechanism was maintained using BibTeX. The graphs have been produced using MS Excel, saving the images as Adobe PDF. Other images were sourced or converted to Adobe PDF. The final printed version has been generated in Adobe PDF format. This same Adobe PDF version will be distributed electronically.

A.2 Shortened URLs in Bibliography

A well-known problem formatting references is the occurrence of long strings in URLs (web addresses) that are difficult to format. I have tackled this problem by maintaining a public registry of URL redirections with the OCLC (On-line Computer Library Center), a nonprofit, membership, computer library service and research organisation dedicated to the public purposes of furthering access to the world's information and reducing information costs. More than 60,000 libraries in 112 countries and territories around the world use OCLC services to locate, acquire, catalogue, lend and preserve library materials.

For this purpose I have registered my own top level domain in the namespace supported by the OCLC. This means that all URLs I create begin with `http://purl.oclc.org/MSOF/`. I then use a simple unique string after this

to keep the URL as short as possible and yet uniquely identify it. Usually this is the surname of the first author, and the date of publication.

The advantages of this approach are that:

1. all such URL redirections I create are public and can be searched by anyone;

2. I have editorial access to these URLs and can update them if needed to keep pointing to a relevant location (so if the page disappears from the web, I can edit the reference URL to point to the archived version of the page on a web archive service, as I have done it in at least one instance);

3. the service is maintained by a reputable third party with excellent library credentials, the OCLC is the primary source for most library catalogues in the world, so that this service is unlikely to be withdrawn due to market pressures (as may be the case with some other free URL redirection services). The PURL service has run reliably since 1995.

The reader does not need to know the explanation above, she or he can simply use the URL cited and it should work, automatically redirecting the request to the longer version of the URL.

For further information see the PURL description maintained by the OCLC at `http://purl.oclc.org/docs/new_purl_summary.html`.

Appendix B

Submissions to OECD Review 2004

Background Country Report — Ireland, Professor John Coolahan 2003/2004
Building Ireland's Innovation Society: An Action Plan for raising Research and Development Intensity to 2010, Draft Report of the ERA Steering Group
Challenge Facing Irish Universities, Workshop and Discussion, Royal Irish Academy, 2003
College Entry in Focus: A Fourth National Survey of Access to Higher Education — Patrick Clancy, HEA 2001
Creating and Sustaining the Innovation Society, HEA 2002
Competitiveness Challenge 2003, National Competitiveness Council 2003
Creating Ireland's Innovation Society: The Next Strategic Step Liam Downey, Higher Education Authority 2003
Department of Education and Science — Review of Department's Operations, Systems and Staffing needs — Cromien Report, DES 2000
Department of Education and Science Statement of Strategy 2003-2005, DES 2003
Euro Student Survey 2000: Irish Report — Social and Living Conditions of Higher Education Students, Professor Liam Ryan and Ms Caroline O'Kelly, HEA 2001
Europe's Search for Excellence in Business Research, Symposium Consensus, Dublin Castle, February 2004
Final Report and Recommendations — Commission on the Points System, 1999
Fourth Report of the Expert Group in Future Skills Needs, Forfás 2003

The Future Funding of the Irish University Sector, CHIU 2003
A Framework for Quality in Irish Universities, CHIU 2003
Higher Education and National Spatial Strategy. Draft Discussion Paper. Skills Initiative Unit, DES 2003
Institutes of Technology and the Knowledge Society — Their Future Position and Roles, Report of the Expert Working Group, Council of Directors of Institutes of Technology 2003
Ireland, knowledge is in our nature, Industrial Development Authority 2003
National Development Plan, Ireland, 2000-2006, Irish Government Publication 2000
National Framework of Qualifications — An Overview, National Qualifications Authority Ireland, 2003
National Framework for Science, Technology and Innovation, Final Report of the ICSTE Commission, December 2002
Policies, Actions and Procedures for the Promotion and Facilitation of Access, Transfer and Progression, National Qualifications Authority Ireland, 2003
Provision of Undergraduate and Taught Postgraduate Education to Overseas Students in Ireland, HEA 2003
The (2+1) and 3-year Structure of Courses, Draft Discussion paper. Skills Initiative Unit, DES 2003
Towards a CHIU Sectoral Research Strategy: The Research Career developing the University Perspective Discussion document, CHIU 2003
Towards an Integrated System of Tertiary Education — A discussion paper. Malcolm Skilbeck, Dublin Institute Technology 2003
Programme for Research in Third Level Institutions — Information Guide, HEA 2001
Report on Symposium on Open and Distance Learning, HEA 2000
Report of the Commission on the Points System, DES 1999
Report of Review Committee on Post Secondary Education and Training Places. de Buitleir, HEA 1999
Recommendation of the Higher Education Authority to government in accordance with the terms of Section 9 of the Universities Act, 1997, HEA 1999
Review of the application by the Dublin Institute of Technology for establishment as a University under Section 9 of the Universities Act, 1997, HEA 1999
Supporting Equity in Higher Education, DES 2003

Task Force on the Physical Sciences Report and Recommendations DES 2002
Technical Working Group on the Review of Outreach Centres of Higher Education Institutions, HEA 1999
Technology Foresight Overview, Irish Council Science Technology and Innovation 1999
Technology Foresight and the University Sector, CHIU 2000
The Financial Governance of Irish Universities — Balancing Autonomy and Accountability, HEA, CHIU 2001
The University Challenged — A Review of International Trends and Issues with Particular Reference to Ireland — Malcolm Skilbeck, HEA, CHIU 2001
Union of Students in Ireland, Costs of College Survey Results 2003, USI 2004
[OECD, 2004, pp. 74–75]

Appendix C

Irish Governments 1989–2008

This description is provided for non-Irish readers of this thesis who may not be familiar with Irish political nomenclature, and with the politics of recent governments. It also serves as a reference point for identifying who was in power as various policy reports and white papers were published, and acts were enacted. It is not designed to be a detailed sociopolitical analysis, but more of a tabular cross-reference of key facts.

The Irish parliament is known as the Dáil Éireann. In Irish political history the numbers of each successive Dáil are traced back to the original government declared by those who boycotted the British parliament, though they were elected to serve in that parliament based in Westminster, in favour of setting up an independent Irish parliament in 1919. The governments up until the creation of a new constitution in the 1930s were known as Executive Councils. After the Anglo-Irish Treaty of 1921 a new parliament was established, recognised by the British as well as the Irish; this is counted as the Third Dáil in Irish history. From 29th December, 1937, on which date the new constitution came into effect, the following changes took place: (i) The Eighth Executive Council became known as the First Government of Dáil Éireann; (ii) The title of President of the Executive Council was changed to that of Taoiseach, and that of the Vice-President to that of Tánaiste. In addition each Dáil represents a period between one election and the next, whereas it is possible, though rare, for there to be more than one Government formed in the duration of a single Dáil. So the numbering of the Dáil and Governments start out of sync, a difference which may change further over the period.

In recent years the 26th Dáil was the 21st Government of Ireland, and was formed in 1989. The make-up of each Dáil and Government since then is described below. The abbreviation TD refers to the Irish term Teachta Dála (TD), which means a deputy to the Dáil, in other words the Irish equivalent of a British

MP (Member of Parliament). The Taoiseach is the Irish equivalent of the British Prime Minister, and the Tánaiste is the Irish equivalent of the British Deputy Prime Minister. The holders of these positions, and their party affiliations are shown for each government, as well as the holders of the two critical ministries for STI policy: Enterprise and Education. Note that on the 21st January 1993 the Department of Industry & Commerce was renamed the Department of Enterprise & Employment and on 22nd July 1997 the Department of Enterprise & Employment was renamed the Department of Enterprise, Trade & Employment. Since 1997 the full title of the Minister for Education has been the Minister for Education and Science, but the department and the ministerial title are still often used in the original (now abbreviated) form. As in the British system Ministers of State are junior ministers; ministers of state in Enterprise and Education are listed where relevant (e.g. where they are named as being involved in a key report being analysed in this thesis).

C.1 26th Dáil 1989–1993; 21st and 22nd Governments

Coalition: Fianna Fáil (FF) and Progressive Democrats (PD)

There were two governments, of the same coalition, in this Dáil due to the resignation of Charles Haughey as Taoiseach on 11th February 1992.
Taoiseach: Charles Haughey (FF) 1989–1992, Albert Reynolds 1992–1993
Tánaiste: Brian Lenihan (FF) 1989–1990, John Wilson (FF) 1990–1993
Minister for Industry and Commerce: Desmond O'Malley (PD) 1989–1993
Minister for Education: Mary O'Rourke (FF) 1989–1992, Séamus Brennan 1992–1993

C.2 27th Dáil 1993–1997; 23rd and 24th Governments

There were two governments in this Dáil, as Labour switched allegiance due to some scandals involving Fianna Fáil.

Fianna Fáil and Labour coalition (1993–1994), Labour resigned from government on 17th November 1994, and thus the government became a minority Fianna Fáil one for a month until it was dissolved by a vote of no confidence on 15th December 1994. During this period the Department of Industry and Commerce was renamed the Department of Enterprise and Employment.

Coalition: Fianna Fáil (FF) and Labour (Lab)

Taoiseach: Albert Reynolds (FF)
Tánaiste: Dick Spring (Lab) 1993–1994, Bertie Ahern (FF) 1994
Minister for Enterprise: Bertie Ahern (FF) 1993, Ruairi Quinn (Lab) 1993–1994, Charlie McCreevy (FF) 1994
Minister for Education: Niamh Bhreathnach (Lab) 1993–1994, Michael Smith (FF) 1994

This was followed by a Fianna Gael, Labour and Democratic Left coalition (1994–1997), known as the Rainbow Coalition.

Coalition: Fianna Gael (FG), Labour (Lab) and Democratic Left (DL)
Taoiseach: John Bruton (FG)
Tánaiste: Dick Spring (Lab)
Minister for Enterprise: Richard Bruton (FG)
Minister of State at the Department of Enterprise (for Commerce, Science and Technology): Pat Rabbitte (DL)
Minister for Education: Niamh Bhreathnach (Lab)

C.3 28th Dáil 1997–2002; 25th Government

Coalition: Fianna Fáil (FF) and Progressive Democrats (PD)
Taoiseach: Bertie Ahern (FF)
Tánaiste: Mary Harney (PD)
Minister for Enterprise: Mary Harney (PD)
Minister for Education: Micheál Martin (FF) 1997–2000, Michael Woods (FF) 2000–2002

C.4 29th Dáil 2002-2007; 26th Government

Coalition: Fianna Fáil (FF) and Progressive Democrats (PD)
Taoiseach: Bertie Ahern (FF)
Tánaiste: Mary Harney (PD) 2002–2006, Michael McDowell (PD) 2006–2007
Minister for Enterprise: Mary Harney (PD) 2002-2004, Micheál Martin (FF) 2004–2007
Minister for Education: Noel Dempsey (FF) 2002–2007, Mary Hanafin (FF) 2004–2007

C.5 30th Dáil 2007–; 27th and 28th Governments

Coalition: Fianna Fáil (FF), Green Party (GP) and Progressive Democrats (PD) supported by four Independents

There were two governments, of the same coalition, in this Dáil due to the resignation of Bertie Ahern as Taoiseach in 6th May 2008. A cabinet reshuffle in March 2010 saw the re-designation of the Department of Enterprise Trade and Employment (DETE) as the Department of Enterprise Trade and Innovation (DETI), and of the Department of Education and Science (DES) as the Department of Education and Skills (DES).

Taoiseach: Bertie Ahern (FF) 2007–2008, Brian Cowen (FF) 2008–
Tánaiste: Brian Cowen (FF) 2007–2008, 2008– Mary Coughlan (FF) 2008–
Minister for Enterprise: Micheál Martin (FF) 2007–2008, Mary Coughlan (FF) 2008–2010, Batt O'Keeffe (FF) 2010–
Minister for Education: Mary Hanafin (FF) 2007–2008, Batt O'Keeffe (FF) 2008–2010, Mary Coughlan (FF) 2010–