

**POLITICAL SCIENTISTS? THE UK KNOWLEDGE ECONOMY AND YOUNG
SCIENTISTS**

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PhD Thesis

Declaration of originality

I hereby confirm that the work in this thesis is entirely my own, and that the work of others included in this thesis, published or otherwise, is fully acknowledged in the bibliography.

I certify that no part of this thesis has been published or submitted for publication.

Sally Hancock, September 2012

Abstract

This thesis is an exploration of the UK knowledge economy, and its implications for the present and future lives of STEM (science, technology, engineering, mathematics) doctoral students at a research-intensive UK university. The research methodology included a critical literature review, focus groups, a large scale survey, and depth interviews.

The thesis reports that the UK knowledge economy is a known phenomenon to young scientists and, across the population of young scientists, five distinct moral positions towards the knowledge economy are discerned. These five moral positions form a spectrum, ranging from ‘anti’ to ‘pro’ knowledge economy. Young scientists’ moral positions on the knowledge economy are revealed to be a key aspect of their scientific identity. That the scientific identities of young scientists are in part moral contradicts dominant images of the scientist who, in Steven Pinker’s words, is often construed as an ‘*amoral nerd*’ (Pinker in Shapin, 2008: xv).

Young scientists’ conceptions of identity are however, notable for their narrowness. Young scientists continue to rely upon the paradigm of modernity when forming their moral position on the knowledge economy, and constructing their identity. Accordingly, they view scientific identity as solid and stable. A game theory informed analysis illuminates how young scientists strategically tailor their scientific life in order to construct and sustain a stable identity; the achievement of which, they believe, is the best preparation for a scientific career.

The irony of this finding is that contemporary science is shaped by *postmodern* forces: the knowledge economy and liquid modernity. These forces generate diversity, contradiction and perpetual change. It is argued that young scientists must develop a *liquid* scientific identity, fit for these conditions. Three reforms of the STEM PhD are proposed to enable universities to support young scientists to ‘*avoid fixation and keep the options open*’ (Bauman, 1995: 20).

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If the modern 'problem of identity' was how to construct an identity and keep it solid and stable, the postmodern 'problem of identity' is primarily how to avoid fixation and keep the options open.

Zygmunt Bauman (1995)

1. Introduction: The scientific state we're in

This project began in 2009, when I was appointed as a research assistant within the Graduate School of a science focused research intensive university in the UK. With a background in politics and social policy, I came to the world of science as an outsider. At the time, I would have stated my primary research interest as higher education as a social policy, in the context of the widening participation agenda and theories of social mobility. I was faced with the task of developing a project that would benefit from my existing skills and knowledge, and be of pertinence to the students at the fore of graduate school's concern: a relatively privileged group of STEM doctoral students; the disciplinary lives of whom I knew very little about.¹

It will become clear that this project follows an idealist, hermeneutic philosophy, meaning that it is not problematic to admit that the subjective experiences of the researcher were influential in the initial formation of the project. In the summer prior, I had interned at the London based think-tank Demos. Science and innovation were cornerstones of its research agenda. Though I did not work on any projects in this stream directly, I remember how central the concept of the 'knowledge economy' was to the researchers involved. This concept was deemed critical by those theorising about the future of UK science and innovation policy.

Partly inspired by my experience at Demos, and its ambition to link the grand ideas of policy with the everyday lives of citizens; and partly wishing to draw upon my background in politics and policy research, the knowledge economy was one of the ideas I considered in the initial scoping of the project. Other potential avenues of research discussed with my supervisors were the experiences of international students at the university, or of women undertaking the STEM PhD. These ideas did not enthuse me in the same way that a project tied to the national policy agenda did. As I have said, part of the reason for this probably owed to my past academic experiences and interests, but I believed also that a project framed around a policy idea would accommodate the exploration of individual differences - such as nationality and gender - at the micro-level, if they proved to add further insight.

¹ Throughout the thesis, I use the label of 'young scientists' to refer to UK domiciled doctoral students in the disciplines of science, technology, engineering and mathematics (STEM). 'Young scientists', is used interchangeably with 'STEM PhD students', 'STEM PhD researchers', 'STEM doctoral students' and 'STEM doctoral researchers'.

The first thing that struck me as I began the critical literature review on the knowledge economy was that when I spoke to colleagues at the university about the project, awareness of the concept was low. The disconnect between the emphasis that I knew politicians and policy makers placed upon the knowledge economy and its salience at the local university level did not unsettle my commitment to the project however. Rather, it raised my confidence, because by stumbling upon this apparent disconnect, I had hope that the project could have a practical impact; raising awareness of the knowledge economy among the university's students and practitioners.

Furthermore, this disconnect alerted me to a potential power imbalance at play between policy-makers and the STEM doctoral students directly affected by their initiatives. As I researched the knowledge economy, I came to see that young scientists were represented as the key to the country's economic prosperity. Whereas I had once taken the view of many HASS (Humanities, Arts and Social Sciences) students - of seeing my STEM peers as more generously funded and desired by employers - I began to question whether the feelings of envy my perception created were misplaced. Knowledge economy policy documents neatly map out the futures of young scientists; their situation as researchers seemed far less free than my own. A rather serious moral question began to take shape. I had perceived anecdotally, that the knowledge economy was a little acknowledged phenomenon in the university, but what did this mean for young scientists? Were they aware of this normative account of science that had the potential to frame their future scientific lives?

Fundamentally, this thesis is a study of *expectations* and *realities*. It is resolutely anti-myth. The contemporary scientific state that we face is governed by the concept of the knowledge economy. It is a concept that shows no sign of losing political influence, having provided a theme of consistency in thinking about higher education, science and the economy from the government of Thatcher to the present day Conservative-Liberal Democrat coalition.

Devising a project that sets out to explore the relationship between expectations and realities is a risk. The most pressing risk that I contended with was the possibility that young scientists had *no* expectations about the knowledge economy and their future scientific lives. Aside from generating data of little interest to report, such a low level of political awareness would of course be problematic, even for those young scientists intending to forge a scientific career within the university. As we shall see, the university assumes a chief place within the infrastructure of the

knowledge economy and consequently, the institution and its staff are expected to evolve for this role. Nevertheless, this concern proved unnecessary because the early focus groups affirmed that young scientists were politically involved and passionately articulate on the value questions of science, society, economics, and politics. Bright and open, I found young scientists to be extremely receptive to the project, and the chance it afforded them to talk broadly about the present and future of their scientific lives, from a horizon that looked further than the everyday grind of library and laboratory.

The interest and assistance of young scientists seemed secure, but of course the other risk I encountered was the prospect of the knowledge economy losing political relevance over the three years of the project, or sometime shortly after. This also proved not to be the case, and moreover, the conclusion of this project goes far deeper than simply considering young scientists' awareness of, and attitudes towards, the knowledge economy. By using a reflexive, iterative approach to the data collection and analysis, I allowed the project to evolve so as to reflect the concerns of young scientists more holistically. It became clear that the knowledge economy is just part of the picture. Scientific identity and career intentions emerge as equally significant parts of young scientists' narratives, and in giving these concerns due attention in the reporting and analysis parts of the thesis, I am confident that its conclusions will stand scrutiny for some time to come. The popularity and vocabulary of the knowledge economy may alter in the coming years, but the issue of young scientists' expectations about science and the reality that they are met with is unlikely to fade.

For the moment, the future careers of STEM PhD students continues to be a significant political topic in the UK. It generates emotive discussion precisely because it provokes the hopes and expectations of early career scientists, and also because the present coalition government is still undecided on how to answer the question of what is best for young scientists. During the second year of the project, I attended a debate at the Royal Institution of Great Britain, entitled '*Science Careers: Has the Science Establishment let down young researchers?*'. David Willetts, the present Minister of State for Universities and Science, sat on the panel. The discussion began with an acceptance that science had fared relatively well - when compared to the HASS disciplines - in the 2010 Comprehensive Spending Review (CSR). At a time of public austerity, the CSR was taken as evidence that the coalition continued to accept the economic utility argument for science, and believed that cuts to its funding would only be detrimental to the long term economic recovery of the UK. Simply put, the knowledge economy still mattered. However, the discussion that followed

focused upon allegations of the poor conditions and prospects for young scientists in the UK. Willetts was asked what he could and would do, within the remit of his Ministerial position, to address the concerns laid out.

These concerns covered an array of issues: cuts to the training budget for STEM PhDs; the lack of academic positions post-PhD; the more generous postdoc salaries offered in America, Germany and Australia; the closure of UK sites by several pharmaceutical firms; and, the replacement of EPSRC project-specific STEM PhD studentships with Doctoral Training Centres (DTCs).² On this latter point, Willetts argued that the scientific community were explicitly consulted about STEM PhD training, and that it was they who had suggested that DTCs were the best way forward. The question that followed, posed by former Liberal Democrat MP Evan Harris, asked *who* the government talks to in their consultations with the scientific community. The purpose of this question was to reveal a situation which is a source of much grievance to the audience - composed mostly of young scientists - that when government working parties are formed, it is senior scientists who are leading experts of their field, who are normally consulted. In certain areas of policy making, this approach is of course hard to fault; but when the policy area concerns young scientists, their exclusion is hard to justify. This is ever more the case when scientific careers have so obviously and so markedly changed in recent years. The senior scientist may in truth have no real claim to expertise when it comes to giving insights into the experiences and challenges of young scientists today.

In the words of Dr Jennifer Rohn, the founding member of the pressure group *Science is Vital*, esteemed scientists are ‘*out-of-touch*’ with the grassroots level of early career scientists, and offer only a rose-tinted account of the present reality.³ Two reflections stayed with me after this debate. The first is that the issue of the expectation and realities of young scientists at the start of their scientific career has not lost political momentum; nor is it likely to any time soon, because by its nature it is a complex question that invokes strongly held beliefs and value-judgements. The second

²Whereas PhD students in the UK have traditionally been awarded funding to work on a specific project, to join an existing research group and find their supervisor in the PI of that group, DTCs bring together a number of STEM PhD students into a cohort, on the basis of an area of shared research. DTCs aim to increase interdisciplinary collaboration, to mainstream transferable skills training, and they allow students four years instead of the traditional three to complete their thesis.

³ ‘Science is Vital’ was originated by Dr Jennifer Rohn to campaign against cuts to the science budget in the 2010 CSR. Its membership is voluntary, and it describes its members as ‘*working scientists, ex-scientists, and non-scientists*’. Having been credited as a persuasive force in ensuring the relatively successful ring-fencing of the science budget in the CSR, it has since moved to campaign on other issues within science. For example, a current campaign is ‘*How do you solve a problem like science careers?*’

is that the UK government has a significant gap in its data for answering policy questions relating to young scientists.

This project is thus an early step - albeit on a micro-level - towards addressing this deficiency. This thesis shares scholarly, in-depth, and recently collected data from young scientists, appropriate to this pressing and ongoing policy puzzle. It serves as a starting point for the inclusion of young scientists in the debate on the knowledge economy; a debate that has to date ignored their voices and instead amplified those from the political and business worlds. The potential of this project to impact upon policy - at both the local and national level - endured as a guiding force throughout.

The thesis is structured as follows. Chapter two analyses the theoretical evolution of the knowledge economy and its expression in the policy literature. Chapter three assess two alternative normative accounts of science - modernity and science studies - that continue to influence understandings of the what, why and how of science, even amidst the contemporary dominance of the knowledge economy. Chapter four describes the chosen methodology of the project, and in chapter five we begin the analysis. Chapter five is split into three parts. The survey and interview data are discussed, and it transpires that young scientists possess moral positions on the knowledge economy. The analysis continues in chapter six, when we see how young scientists' moral positions not only inform their scientific identity, but also their behaviour and career planning. In chapter seven, the implications of these findings are discussed. I argue that these moral positions, and young scientists' constructions of identity, are poorly informed and chained to the outdated paradigm of modernity. I argue that young scientists ought to be encouraged to develop a '*liquid*' conception of scientific identity, and propose three reforms to the STEM PhD to facilitate this. It is asserted that, at present, the STEM doctorate does not accommodate the space that young scientists need to develop a robust identity for the knowledge economy. Chapter eight concludes the findings and arguments of the thesis, and contemplates avenues for future research.

2. The evolution of the knowledge economy

2.1 Introduction

This critical literature review is divided into two parts. In this chapter, I will explore the diverse theoretical foundations of the knowledge economy (2.2), before turning to look at its realisation in UK policy (2.3). In conclusion (2.4), it will be argued that the rich and contested legacy of the knowledge economy is undermined by the policy narrative, which characterises the concept as narrow, specific and homogeneous. This is significant because, with the support of the political and business community, it is the policy definition of the knowledge economy, and the purpose of higher education and science articulated within it, that is likely to shape public understanding. Allowing one vision of the knowledge economy, higher education and science to dominate the policy narrative, at the expense of alternative understandings, is akin to myth creation. It is dishonest and anti-democratic.

In the second part of the critical literature review (3), I will consider two alternative accounts to the policy narrative of the knowledge economy. The first is that of modernity; in particular, we will look at what the dominant normative paradigm of the late 18th to the late 20th century had to say on the university, science and scientific identity (3.2). Secondly, we turn to the critical viewpoint of science studies, which tells an altogether different story of the how, what and why of scientific knowledge production (3.3). The purpose of the critical literature review is to set the parameters of the context in which we will analyse young scientists' reactions to the policy narrative of the knowledge economy. This precursory consideration of other highly influential ideas about science, education and the economy, will serve to deepen our understanding of the data when it is discussed in the later chapters of the thesis.

2.2. The theoretical foundations of the knowledge economy

The theoretical basis of the knowledge economy is a combination of old and new ideas. While it is undeniably anchored in capitalist ideology, it additionally promotes new ways of thinking about economics, politics, epistemology, science, and education. It is more than a '*discursive recasting*' of the relationship between knowledge and the economy, as suggested by Bastalich (2010: 845); because from the platform of theory, tangible policies have followed and changes in the behaviour of agents can be observed. For the moment however, our purpose is to focus upon the theoretical grounding. A summary of our ensuing discussion can be found in figure 2.1 (p. 31).

2.2a Reconceptualising economic theory

In this section, I will discuss the changes in economic thinking that led to knowledge being reconceptualised as an economic commodity. I address political theory separately, in the next section (2.2b); however, I do not wish to imply that economic theory is apolitical. On the contrary, I will show that the economic reasoning of the knowledge economy rests upon a preconceived interest; that of profit-maximisation. Knowledge economy theory is the latest product of capitalist ideology (Rikowski, 2003: 160). Steve Fuller is right to name it '*capitalism of the third-order*' (Fuller, 2003: 103).

The capitalism that historically flourished in Western Europe and America was grounded in classical liberal economics and a commitment to the free-market. As with most economic and political doctrines, classical liberal economics rested upon assumptions about human nature. It supposed that individuals were rational, freedom-maximising agents who should be at liberty to pursue profit through the market. Since the market was understood to possess an intrinsic equilibrium, distributing just deserts, it followed that a minimal state was thought to be the best form of government. Individuals would compete with one another within the market, with minimal obligations to one another and the state.

Friedrich von Hayek is perhaps the best known theorist of classical liberal economics. Significant to our present discussion, Hayek argued against the monopolisation of knowledge creation and application in the free market. He proclaimed:

The utilisation of knowledge is not given to anyone in its totality.

(Hayek [1937], cited in Peters and Humes, 2003: 4)

Hayek's advocacy against the monopolisation of knowledge supported his broader anti-totalitarianism stance, and his fear that monopolies were a sure route to tyranny (Hayek [1944] 2003: 200). His wariness of monopolies was shared by other classical economists. Specifically, Hayek opposed the notion that the university should dominate the ownership of intellectual property. Hayek believed that knowledge ought to flow freely across society for optimal economic productivity. If the university could restrict access to knowledge, by demanding payment first, then overall economic productivity would be depressed. In any case, Hayek believed that attempts to

commodify knowledge would prove to be inefficient. Hayek postulated that, in practice, private corporations could not monopolise knowledge in such a way as to prevent others from profiting from it. Furthermore, a private corporation had little incentive to form a monopoly because, unlike most economic commodities, the value of knowledge would not diminish with greater use.

It is on the issue of the commodification of knowledge that *neoliberal* economics departs from its classical forefather. Neoliberal economics has become the dominant economic model for advanced and developing economies since the 1980s. It is often referred to as the ‘Washington Consensus’, due to its association with the American Treasury and Washington-based monetary institutions such as the World Bank and the IMF (International Monetary Fund). Like classical liberal economics, it is anchored in capitalist values. However unlike classical liberal economics, neoliberal economics asserts that knowledge should be commodified and demonstrably contributes to economic growth.

Joseph Schumpeter provided the first compelling evidence that knowledge-intensive innovation ought to feature in models of economic growth in his posthumously published *History of Economic Analysis* (Schumpeter, 1954: 1028). Schumpeter proposed that new knowledge unleashed ‘*gales of revolutionary creation*’; generating new industries, employment and wealth but often destroying older, less efficient practices in consequence (Dodgson and Gann, 2010: 20) According to Schumpeter, the survival of any product depended upon its continual improvement, made possible by incremental advances in knowledge. Schumpeter celebrated risk-taking entrepreneurs and recommended that corporations should seek to emulate this through investments in in-house research (Ibid.: 22).

Endogenous or *new growth* theory built upon Schumpeter’s position to generate the organising principles of neoliberal economics. Endogenous growth theory states that long-term economic growth depends upon investments in technology and the presence of skilled workers (Crafts, 1996: 30). It is therefore imperative that neoliberal economic regimes invest adequately in human capital, knowledge creation and innovative application if they wish to see long-term economic growth (Craig and Gunn, 2010: 4). The notion that ‘*ideas and brainpower*’ will determine future GDP is an attractive one in contemporary advanced economies, where the profit potential of raw materials and manufacturing is in a visible decline (Caulkin, in Rikowski: 161).

The neoliberal world-view is not wholly without criticism. The former Chief Economist of the World Bank, Joseph Stiglitz, publicly agreed with Hayek's original position, describing knowledge as 'non-rivalrous' and 'scarcity-defying' (Stiglitz, 1999: 8, 10). For this reason, Stiglitz believed that generating a profit from knowledge depended upon shrewd policy and regulation. Most neoliberal economists in fact agree with Hayek's assertion that the abundance of knowledge does not lead to a depression in economic value. For neoliberals, this means that the profit potential of a piece of knowledge is infinite. Basic and generally un-patented knowledge is a huge, untapped resource for private corporations; they can exploit it and profit from it, without necessarily having to invest in it. From basic knowledge, applications are assumed to evolve; these can be patented and can thus lead to a clear financial return. In knowledge economy theory, it is supposed that the state will be the greatest funder of basic research, from which the invisible hand dictates that competition between corporations will ensue, and profitable innovations will result.

The neoliberal economic model confers upon the state a responsibility for nurturing human capital, securing basic knowledge creation, and encouraging innovation. Accordingly, knowledge economy thinking has prompted a new wave of political theory.

2.2b Reconceptualising political theory

Policy makers have long thought about the utility and value of knowledge (Delanty, 2003: 73). Knowledge economy policies can therefore be seen as representing a gradual transformation in political thought, rather than as constituting an entirely new policy area (David and Foray: 20). In neoliberal knowledge economies, the role of the state is to stimulate and regulate the economy. Stimulation occurs from state investment in research and development (R&D) and human capital; whereas regulatory activities typically refer to the development of intellectual property law and favourable tax regimes for corporate R&D activity.

Neoliberal knowledge economy policies make an implicit comment on human nature. The neoliberal model assumes that individuals are self-interested, profit-maximising agents. The financial ambitions of the individual are assumed to override their concerns for a just society. This take on human nature is historically consistent with liberal ideology and can be traced back to Thomas Hobbes' classic defence of liberal individualism in his 1651 work *Leviathan*. *Leviathan* emphasised the solitary and competitive nature of man; but we must be mindful that it is but one account of human nature, and that the later account of Jean-Jacques Rousseau, *On the Social*

Contract (1762), could not have provided a starker contrast. Rousseau alternatively hypothesised that man tended towards societal-conscientiousness and compassion, and his work is considered a seminal text in early socialist thought

The question of human nature has animated political philosophy for centuries. The interesting feature of neoliberal knowledge economy theory however, is that we can discern an attempt to reach a position of compromise between Hobbes' *nasty, brutish* and egocentric indigene, and Rousseau's *noble savage*. This compromise becomes clear when we look at how individual freedom is conceived in the neoliberal knowledge economy. To employ the classification of Isaiah Berlin, Hobbes and classical liberals would expect an individual to thrive in a context of '*negative freedom*', wherein they enjoy freedom from the constraints of government and others (Berlin, 1958: 7). The neoliberal encouragement of entrepreneurial individuals and low corporation tax fit well with this laissez-faire approach. Additionally however, we see an articulation of '*positive freedom*', or 'freedom to do' in the neoliberal knowledge economy (Berlin: 16). The positive model of freedom requires a more involved and socially-minded government, evidence of which can be found in the interventionist policies designed to cultivate highly-skilled and ambitious individuals; for example, raising the UK school leaving age to eighteen and advocating mass participation in higher education. The rationale behind these education policies is that an individual will need initial support to develop their knowledge and skills, before they can flourish freely.

Far from giving rise to theoretical disorder; the classical, neoliberal and socialist melee of the knowledge economy found coherence of expression within a new political vision, that of the *third way*. The chief intellectual architect of the third way was the sociologist Anthony Giddens. Giddens saw the third way as a necessary compromise between neoliberal and socialist doctrines, since he believed neither approach, in isolation, would be sufficient to deal with the challenges of the contemporary age (Giddens, 1998: 3, 55). In Giddens' words, the third way is:

An attempt to transcend both old-style social democracy and neoliberalism.
(Giddens, 1998: 26)

Towards the late 1990s, a critical time for the development of knowledge economy policies, the third way was beginning to supersede the popularity of neoliberalism in many advanced western economies (Delanty, 2003: 75). Nico Stehr's *The Knowledge Society* (1994) is a key addition to third-way theory. Stehr noted the growing importance of knowledge to all aspects of economic and

social life in advanced economies; but he was keen also to highlight the importance of knowledge for the individual. For Stehr, knowledge represented a capacity to act; it could change human behaviour and its possession could improve individual life-chances (Stehr, 1994: 5).

In Stehr's society, knowledge has emancipatory potential. Knowledge-rich individuals can better their own living conditions and bring about social change, through democratic participation. The elitism of industrial capitalism is also challenged in Stehr's knowledge society, since accumulating wealth depends less upon inherited capital and more upon intellectual ability. Furthermore, developing one's intellect is something open to the many rather than the few, because of mass higher education systems (Stehr: 36). The earlier work of human capital theorist Gary Becker provided data to substantiate Stehr's optimism, by demonstrating that education was positively related to both individual earning potential and societal equality (Becker, 1993: 108). On the basis of his findings, Becker recommended that governments must invest in education and training if they wished to preside over rising living standards and long-term economic growth (Becker: 23-5). As we shall see later in this chapter (2.3), UK governments reacted to this vision with several commensurate policies.

Stehr elaborated Becker's analysis by suggesting that, economic rewards aside, knowledge-intensive work was inherently more satisfying for the individual. Stehr's proposition echoed the sociologist Karl Mannheim, who had previously stated that knowledge work fostered a higher sense of self-worth for the individual, which was in itself more greatly valued than any financial benefit ([1952] 2000: 261). The expected result is a self-perpetuating cycle, wherein the strength of a national knowledge economy grows as the country's workers strive to attain higher education qualifications in order to secure knowledge work (Stehr: 114).

2.2c Reconceptualising epistemology

Epistemology is an account of the nature and scope of knowledge. Towards the end of the twentieth century, the authority of the dominant epistemologies of that century - drawn from the Enlightenment, modernity, and positivism - were called into question. This crisis of confidence owed to the postmodern turn; an event that allowed for the subsequent rise of knowledge economy theory.

The postmodern turn announced the death of the *'orthodox narratives'*, or epistemologies, of society (Delanty, 2003: 74). The orthodox epistemologies had conceived of knowledge as an objective, apolitical and inherently useful property. Discovered by experts through the scientific method, knowledge shone light upon the truth of the universe, and was thus valued for its own sake. Postmodernism resolutely rejected this account of knowledge; proposing instead that all knowledge claims are in part socially constructed. Reality is not wholly objectively 'known', but in part socially and subjectively experienced. There is not one universal truth, but many apparent realities; subjectively interpreted and shared.

In 1979, Jean-Francois Lyotard was commissioned by the Conseil des Universités du Québec to report on the state of knowledge at this turbulent time. Lyotard's report was entitled *'The Postmodern Condition'*, and it concluded that knowledge, in the wake of the postmodern turn, faced a crisis of legitimacy. The authority of the orthodox narratives, and the faith that people once placed in them, had fallen away (Lyotard, [1979] 1984: 3). Michel Foucault supported Lyotard's diagnosis, explaining that the narratives of the modern age had been nothing more than representations of power (Foucault, 1986: 73). The epistemologies of old told us little about truth; but much about the distribution of power in society. Lyotard was certain that the postmodern perspective provided the right means forward. He explained, *'I define postmodern as incredulity towards metanarratives'* (Lyotard, [1979] 1984: xxiv). This incredulity would enable man to expose those powerful vested interests pertaining to represent truth, and move closer towards the real thing.

The problem is that in the wake of the postmodern turn, deciding on what counts as real or valid truth becomes incredibly complex. Some postmodernists assert that all claims of knowledge should be treated as nothing more than mere claims; and that since there is no meaningful way to distinguish between various claims, society should make peace with a condition of epistemological relativism. In chapter three, I will discuss in detail the narrative of the modern university, and highlight the particular problem that postmodernism caused for its coherence and status. For our present purposes, it suffices to say that in a scenario of epistemological relativism, the historic position of the university as purveyor of expert knowledge would be threatened. Nonetheless, we know that in recent decades, the demand for a university education, expert knowledge and evidenced-based policy has increased. The power and status of the university has continued; its narrative has faced some revision. The theory of the knowledge economy salvaged knowledge from its beleaguered postmodern state, and revitalised the potentially enfeebled institution of the

university. The knowledge economy has assumed the characteristics of a narrative fit for modernity; full of certainty and future-facing. It has recast the epistemological agenda; replacing ‘truth’ with ‘economic utility’ as the axiomatic value of knowledge. As we will see in section 2.3, when the policy-makers of today seek to justify public expenditure in knowledge, they do so not by promising truth, but by assuring economic growth.

Where knowledge economy theorists and policy-makers lack consensus, however, is on the detail of *how* knowledge translates into economic growth. This leads to a further point of disagreement: which types of knowledge ought to be classified as economically useful. Utility is a subjective matter, and one can think of manifold categorisations: political, economic, technological or social. Theorists argue ceaselessly over this disputed ground. The sociologist Helga Nowotny proposes that social utility ought to be a guiding principle for scientific knowledge production, since what is good for society will inevitably have a commercial value (Nowotny et al., 2002: 35 and 174). Most theorists however have stressed that economic utility, in other words potential for profit, should come first in knowledge economy policy. This perhaps affirms Steve Fuller’s observation that ‘social utility’ is too elastic a concept to be of use in constructing a robust epistemology. The vagueness of what is ‘social’ and what is ‘useful’ means that it is very easily co-opted into the interests of the rich and powerful (Fuller, 1999, cited in Jacob, 2003: 129). The lack of consensus in knowledge economy theory regarding the exact relationship between knowledge and the economy, and indeed, which types of knowledge we should invest in most heavily, affords policy-makers a great liberty when it comes to setting the policy agenda. In 2.3, we will trace how a very particular view of the knowledge economy came to find expression in UK policy, and, in contrast to the diverse theoretical literature presented here, there are grounds to believe that arbitrary selections, made to fit prior political and financial positions, underpin the evolution of UK knowledge economy policy.

2.2d Reconceptualising science and technology

Since profit is most prized in the knowledge economy, types of knowledge that are believed to yield a financial gain develop most rapidly in such regimes (Winch, 2003: 67). This is because types of knowledge that are expected to be profitable receive the most investment in knowledge economies (David and Foray, 2003: 21). A number of influential knowledge economy theorists, and the majority of policy-makers, tell us that scientific and technological knowledge is of most economic value, and therefore deserves the most political and financial attention (Ibid.: 22).

In this section, I will introduce the work of Fritz Malchup, Daniel Bell and Manuel Castells, together with the 'science push' model of innovation. In all of these accounts, emphasis is placed firmly upon techno-scientific knowledge as the key ingredient for economic growth. Fritz Malchup's *The Production and Distribution of knowledge in the United States* (1962) is the earliest account of America's transition to a knowledge-based economy. Using a retrospective analysis, Malchup revealed the growth of knowledge industries and knowledge workers in twentieth century America. He suggested that the USA had begun to function as a knowledge economy in the 1960s, and that Western Europe, Japan, and other advanced economies were following (Malchup, 1962: 396). Daniel Bell developed the central premise of Malchup's work. Bell had already speculated in his 1960 work *The End of Ideology* that, akin to the effect of the postmodern turn, the breakdown of the last grand narrative - Marxism - as a cogent universal framework, rendered advanced nations as ready and willing to organise themselves around the principles of '*technocratic guidance*' (Bell [1960] 1988: 298).

Bell's later work, *The Coming of Post-industrial Society*, predicted the steady rise of knowledge economies, and named techno-scientific knowledge as the '*axial principle*' of economic development. This meant that techno-scientific knowledge was to overtake raw materials and industrial output in terms of profit potential, and that it would transform the occupational system (Bell, 1973: 13). Bell believed that knowledge work would come to sit at the top of the occupational hierarchy, a view complemented in the later writings of Stehr and Becker (Ibid.: 14). Bell foresaw an increase in degree-educated workers; and especially in the number of scientists and engineers. Bell urged the governments of advanced economies to plan for the future he presented. He recommended that business and education policy must be tailored to the needs of the knowledge economy (Ibid.: 26). State, society and the economy were to be united by the goal of maximising scientific knowledge production (Ibid.: 25). The experience of the Second World War cemented Bell's belief in the indispensable role of techno-scientific prowess in determining economic competitiveness (Ibid.: 24). In Bell's knowledge economy, techno-scientific knowledge achieves a historically unparalleled political and economic status; if Bell had one reservation about the future, it was that the scientific community may become unaccountable to society (Ibid.: 43, 391).

The sociologist Manuel Castell introduced the term '*network society*', a mode of organisation that can be seen to co-exist with the knowledge economy. The network society describes advanced

economies, which are dependent upon information flows to further development (Castells, 1996: 3). The network society is itself knowledge-intensive; made possible only 'by revolutions in microelectronics' (Ibid.: 9). Castells proposes that networks exist within a marketplace, meaning that they can be either collaborative or competitive, and that information is a commodity (Ibid.: 3). For Castells, the network society is the product of knowledge-intensive institutions: universities, industrial R&D, and independent research institutes (Ibid.: 29). Like Bell's post-industrial society, Castells views the network society as an inevitable state of affairs, made possible by techno-scientific knowledge and driven by the quest to profit from it. Nico Stehr's knowledge society similarly prioritised the economic potential of techno-scientific knowledge (Stehr: 37). Citing Georg Simmel, Stehr argued that the fast pace of techno-scientific knowledge creation was not simply the result of financial interest, but also of human nature. For Simmel and Stehr, practical problem-solving was more important to man than abstract philosophical inquiry; the knowledge economy was thus based upon what mattered in everyday living (Stehr: 91).

As suggested by the label 'techno-scientific', in much knowledge economy theory, science and technology are seen as parts of the same system. The bundling together of science and technology in this way presents a historic rupture with traditional understandings. In 1871, the French chemist Louis Pasteur notoriously remarked, '*there are sciences, and there are applications of science*'. In knowledge economy theory, the idea that investments in basic science will generate profitable technological applications proliferates, yet this view is often criticised by science studies scholars for being too simplistic; a position that we shall consider in depth in the next chapter (3.3). The historian of science Donald Cardwell, for example, reminds us that technology often precedes and advances the development of scientific knowledge, and is far from dependent on it (Cardwell, in Rousseau and Porter, 1980: 480).

A further prevalent assumption in knowledge economy theory is one of a linear trajectory of growth. The suggestion is that greater input - human capital and investment in techno-scientific knowledge - will lead to greater output - technological application, innovation, product and profit. This is the logic of the 'science push' model of innovation, which found popularity in America after the second world war (Dodgson and Gann, 2010: 22). Riding on the success of the Manhattan Project, Vannevar Bush, America's first Presidential Scientific Adviser, pursued a national policy of mass, open-ended basic scientific research. The huge expenditure was justified by the premise that

all innovations were rooted in basic research. Despite a lack of significant evidence, the ‘science push’ model continues to be expressed in contemporary knowledge economy policies.

2.2e Reconceptualising knowledge management

Not all knowledge economy theorists are satisfied with the linear trajectory approach. An alternative view, rooted in management theory, presented a far more nuanced view of the complexities of knowledge creation and application.

The management theorist Peter Drucker first suggested that the management of knowledge, rather than the sheer accumulation of it, would be decisive in the development of prosperous knowledge economies. His 1967 work *The Effective Executive*, explicated the need for knowledge on knowledge, or meta-knowledge. Micromanagement was key in the knowledge economy, and Drucker accurately foresaw the growth in high-value consultancy, management, and market-research. Two years later, in *The Age of Discontinuity* (1969), Drucker confidently stated that most jobs would soon be either knowledge-intensive professional, managerial or associate professional.

For Drucker, knowledge management is of equal importance to techno-scientific knowledge in any knowledge economy (Drucker, 1967: 51). Moreover, skilled knowledge-managers often did not emerge from the STEM disciplines. Rather, tacit and local knowledges are highlighted. In *The Effective Executive*, Drucker explains how ‘theoretical’ scientific knowledge must be combined with the tacit knowledge of managers in order to see an idea through to the point of commercially viable product. The attraction of Drucker’s analysis is that it pays attention to the social, political, and economic variables that determine the value of a commodity. STEM knowledge needs to have a market, and to be well marketed. Knowledge managers, with expertise on the market, need to be on hand to ensure that repetition is avoided and that knowledge with profit potential is not overlooked in the information age. As techno-scientific knowledge-workers become increasingly specialised in the sub-branches of disciplines, Drucker’s worry was that profit-making opportunities would be lost through narrowness of vision, and his solution of knowledge management experts with a commercial eye, makes for a very plausible scenario (Ibid.).

Gibbons et al.’s study of *The New Production of Knowledge* builds upon the breadth of Drucker’s knowledge economy analysis. Gibbons et al. categorise knowledge into two types: *mode 1* knowledge - associated with the modern period, characterised by strict disciplinary boundaries,

mostly basic and produced by the university; and *mode 2* - multidisciplinary, responsive to real-world problems and co-produced by a plethora of interested stakeholders: industry, government, university, independent research organisations and the public. The central argument of Gibbons et al. is that in the context of the knowledge economy, mode 2 knowledge will be most in demand. In contrast, the creation and application of mode 1 knowledge is expected to decline.

Like Drucker, Gibbons et al. stress that problem-solving in the knowledge economy requires knowledge-workers who are not simply expert in STEM, but who have an awareness of relevant social, political and economic forces. In addition, they must demonstrate creativity, possess excellent communication skills, and the ability to reapply knowledge from prior or other contexts to the problem at hand. Since most individuals are unlikely to be adroit in all of these skills, Gibbons et al. predicted a rise in large, multidisciplinary research teams in the knowledge economy, composed so as to transcend the restrictive approach of mode 1 inquiry. Gibbons et al.'s model seems highly in tune with many areas of contemporary public policy. One only has to think of the ethical questions thrown up by stem cell therapies; the assessment and management of risk in nuclear power; or of climate change mitigation policies and the lifestyle changes that they imply, to see that scientific evidence alone is seldom sufficient. Other areas of expertise - often from the HASS disciplines - may need to be called upon; and in any case, there will be a political judgement to make, resting upon a value question that science could not single-handedly answer.

Gibbons et al. championed creativity as an especially significant trait in knowledge workers, because financial profit can only be derived when a solution is novel and superior to those that have passed before (Gibbons et al., 1994: 60). Knowledge-workers who can adopt a multidisciplinary mindset and produce creative solutions were expected to be handsomely remunerated, as per the visions of Bell, Stehr and Becker (Ibid.: 61). The unprecedented sophistication of the knowledge economy meant that, like Drucker, Gibbons et al. concurred that expert knowledge managers would also be essential for knowledge-intensive firms wishing to secure their long-term fortune (Ibid.: 60).

2.2f Reconceptualising higher education

Universities - producers of knowledge workers and techno-scientific innovation - are a key part of the knowledge economy infrastructure. Universities in western advanced economies do not seem to have resisted the rise of knowledge economy theory, and it is reasonable to suggest that this acceptance owes in part to an ongoing global financial recession and retrenched public funding for

higher education. The knowledge economy increases the number of potential investors in higher education, and presents a reworking of the traditional contract between education and the economy.

Knowledge-workers graduating from university are expected to be highly skilled and adequately flexible so as to cope amidst a rapidly changing labour market (Prokou, 2008: 388). Knowledge economies need lots of such workers, meaning that higher education provision must operate on a 'mass' basis. In section 2.3, we will observe how successive UK governments have urged more young people to attend university. The cost of massification has increasingly shifted to the individual student, who is told that this measure is justified given that they will enjoy greater life-long earnings than their non-university educated peers (Mayhew et al., 2004: 68).

Universities in the knowledge economy face several measures of how well they are performing. With regard to human capital, *employability* refers to an individual's ability to be employed in a graduate job, maintain that job, and obtain a new one if required (York and Knight, 2004: 3). It serves as an indicator of institutional performance, since universities, departments, and degree programmes strive to demonstrate that the employability of their graduates is superior to those of other institutions and courses. Employability for the knowledge economy means that graduates need to be highly skilled, able to multitask, and prepared for the reality that a job for life is a thing of the past (Brown and Sease, cited in Prokou: 388). Later in the thesis, in chapter seven, I critically assess the 'attribute lists' increasingly used by UK universities to ensure that their graduates are fit for the tests of the knowledge economy. As we turn to the analysis of UK policy (2.3.), we will see that in line with the epistemology of the knowledge economy, STEM graduates are expected to be the most desired workers in the knowledge economy, thus possessing the most robust employability.

In recent years, the notion that both job and financial security await the university graduate stepping into the knowledge economy has been exposed as something of a myth, most notably by the work of higher education theorists Hugh Lauder, David Ashton, Philip Brown, and Anthony Hesketh.⁴ As McNair has pointed out, the massification of higher education in the UK has created a saturated

⁴ The research of these scholars has focused upon exposing the '*broken promises*' of the knowledge economy. Particularly, they are concerned with the fate of young, highly-educated knowledge workers, since they believe that the economic projections of knowledge economy policy are incorrect, and that the meritocratic vision of social mobility is a myth that will deliver only disappointment. This position is explicated in the following titles: Brown, P. and Hesketh, A. (2004) *The Mismanagement of Talent*. Oxford: Oxford University Press; Brown, P., Lauder, H. and Ashton, D. (2011). *The Global Auction*. Oxford: Oxford University Press; Lauder, H. et al. (2012). *Educating for the knowledge economy?* Abingdon: Routledge.

graduate labour market (McNair, 2003). Nonetheless, the appeal of the knowledge economy account of higher education endures. Firstly, one suspects that while awareness that having a university degree no longer assures one of financial independence, fear of the consequences of not having a university degree is greater. Secondly, leaving economics aside for one moment, it seems plausible to suggest that in an increasingly complex and technology driven world, the possession of higher knowledge can only be a good thing. In his reflexive modernisation thesis, Anthony Giddens suggests that the construction of a '*coherent and rewarding*' identity rests upon a robust knowledge base (Giddens, 1991: 75). As the thesis develops, we will see how the project of identity in the knowledge economy arises as perhaps the most important issue of all. Living well in the knowledge economy might demand a higher level of skills and knowledge than ever before, but these skills and knowledge need to be expressed within an identity that is flexible enough to handle the uncertainty and contradictions of the time.

Universities in the knowledge economy are re-cast as engines of techno-scientific innovation. As we turn to look more closely at UK policy, we will see how - rhetorically at least - universities are now treated as businesses, operating within a competitive market-place. Consequently, it is supposed that they will assume an '*entrepreneurial*' character in the knowledge economy. The entrepreneurial university is expected to deliver patents, develop start-up and spin-off companies, and engage with collaborative R&D projects, particularly with private enterprise. Knowledge economy theorists urge universities to accept this multifaceted role, with one recent publication declaring that their willingness to do so will remedy '*economic failure and social distress*' (Greene, Rice and Fetters, in Fetters et al., 2010: 1). Curricula are redesigned in conjunction with corporate partners, and knowledge-transfer offices spring up in order to act as incubators for translating research findings into commercial ventures. With the entrepreneurial model comes a rise in university staff who specialise in meta-knowledge; in other words, professionals who fit the criteria of Drucker's 'knowledge managers'.

Scholars of higher education have responded to the entrepreneurial model with a mixed reaction. In 1997, Slaughter and Leslie spoke of '*academic capitalism*': proposing that academia was at risk of corruption by the knowledge economy. Later work by Slaughter and Rhodes linked the rise of academic capitalism with a fall in academic freedom and research quality (Slaughter and Rhodes, 2004: 201). In his '*marketisation*' thesis of 1997, Simon Marginson suggested that the employability agenda now dominated students' motivations for participating in higher education,

and that universities had indeed come to act like private corporations (Marginson, 2007: 11, 43-51). Steve Fuller judged the effects of the knowledge economy to be constraining, rather than empowering, the university. He viewed the entrepreneurial model as reductive, stating that the university's mission had been narrowly distilled into two functions: '*dispensers of credentials and engines of economic growth*' (Fuller, 2003: 119).

Knowledge economy theorists would no doubt rebuff these concerns as misplaced nostalgia. Bell warned the university that it would have to adapt in order to deal with competition from rival knowledge-intensive institutions in post-industrial society (Bell, 1974: 118) Drucker was more scathing, calling for nothing less than a complete transformation in the functions of the university. Disinterested academic inquiry aggrieved him; in his view it: '*destroys knowledge* [because it]... *deprives it of its beauty and effectiveness*' (Drucker, 1967: 53). UK policy similarly seems to lack sympathy for the view that the modern university - an image that we will examine in chapter three - is something to cherish.

Etzkowitz and Leydesdorff offer a more balanced view of the relationship between the university and the knowledge economy. In their *triple helix* model of university, government and industry, the university evolves in response to the knowledge economy. They admit that some of the consequences are beneficial, such as access to new funding sources and heightened profit (Etzkowitz and Leydesdorff, 2001: 155-156). Moreover, Etzkowitz and Leydesdorff remind us that the university is only part of the knowledge economy because it is *needed*. Universities ought to recognise the power that they command in the knowledge economy, and to shape their relationship with the state, society and the economy in a favourable way. For example, this might mean that a surplus from profitable areas of research is directed into less profitable areas of basic research, allowing these projects to continue without a compromise on academic freedom (Etzkowitz and Leydesdorff: 25-6).

2.2g Reflections on the theoretical foundations of the knowledge economy

We have seen that the knowledge economy is a complex and multidisciplinary concept, which brings together theory from economics, politics, epistemology, education, sociology and philosophy. Its rich theoretical heritage is summarised in figure 2.1 below.

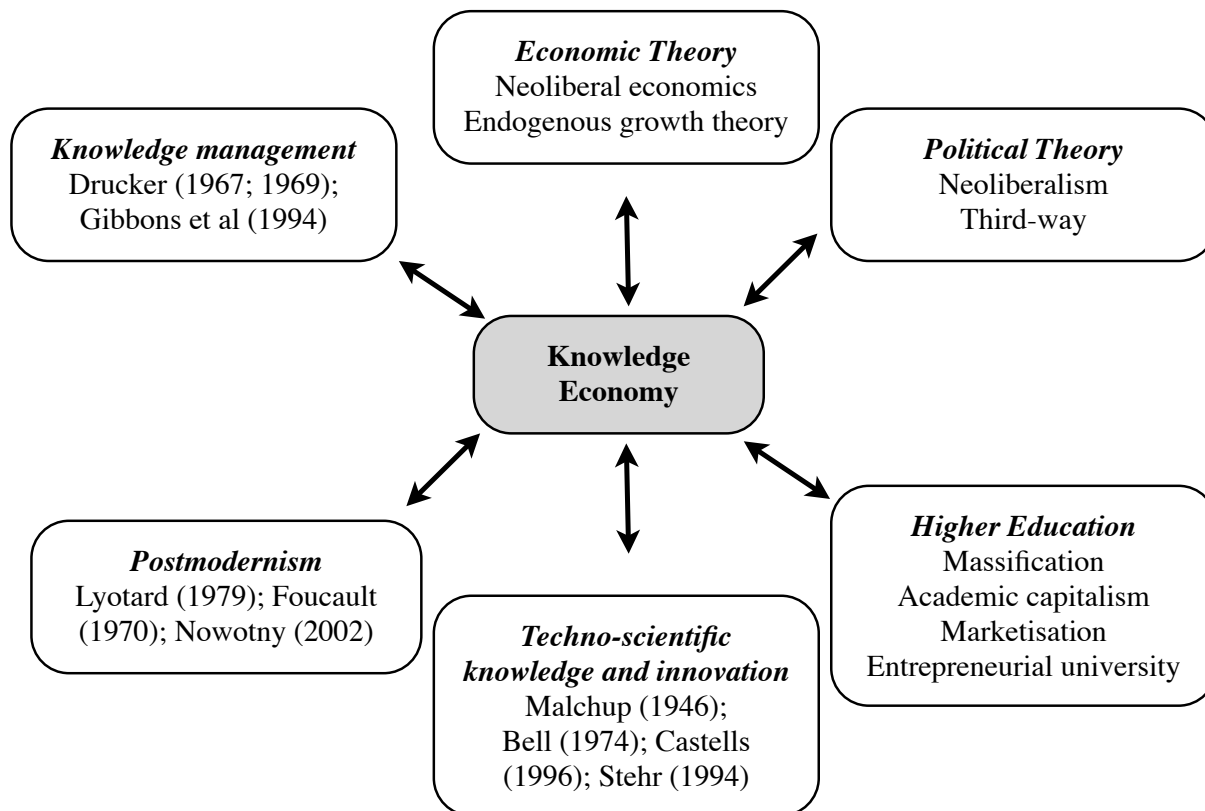


Figure 2.1 The theoretical foundations of the knowledge economy

Within this theoretical diversity, the basic agreed principle of knowledge economy theorists appears to be that knowledge, captured in human capital and innovation, is key to the future growth of advanced economies. Nevertheless, we can identify several points of contention between theorists. Disagreements pivot around the following issues: the varying degrees of importance ascribed to specific knowledge types; whether the knowledge economy is seen as an economic or social theory; and, whether it is a positive or negative development. Table 2.1 below outlines the different emphases of the major knowledge economy theorists examined in our discussion thus far.

| Theorist | Term | Date | Thesis |
|------------------------|--------------------------------|-------------|---|
| Peter Drucker | <i>Knowledge economy</i> | 1969 | Techno-scientific knowledge alone is insufficient for economic growth; the knowledge economy needs knowledge managers who are experts in meta-knowledge and possess tacit knowledge |
| Daniel Bell | <i>Post-industrial society</i> | 1973 | Theoretical, techno-scientific knowledge is the basis of the knowledge economy |
| Michael Gibbons et al. | <i>Contemporary society</i> | 1994 | Techno-scientific knowledge must be blended with other disciplines in order to solve the grand challenges of contemporary society |
| Nico Stehr | <i>Knowledge society</i> | 1994 | Techno-scientific knowledge is essential for economic growth; however the knowledge economy will flourish because it reflects human nature and because man desires knowledge work and the higher living standards of the knowledge worker |
| Manuel Castells | <i>Network society</i> | 1996 | Theoretical, techno-scientific knowledge is the basis of the knowledge economy; it supports both the communications infrastructure of the knowledge economy and produces commercially valuable knowledge-intensive products |
| Helga Nowotny | <i>Age of uncertainty</i> | 2002 | Techno-scientific knowledge ought to be directed towards social needs, and the public should be more engaged in setting the scientific agenda, at an earlier point in the creation of scientific knowledge |

Table 2.1 The diversity of knowledge economy theorists

It is striking that even the matter of using the term ‘knowledge economy’, to describe the contemporary relationship between knowledge and the economy, is an issue upon which theorists cannot agree. In the final part of this chapter I will turn to look at the story of the knowledge economy in UK policy. I will suggest that the theoretical heterogeneity of the knowledge economy, together with the dissension among its scholars, has enabled policy makers to champion a particular, arbitrarily favoured version of the knowledge economy, with little accountability for doing so. We will see that the policy narrative of the knowledge economy has risen to dominance, and I will argue that its narrow account of the nature and value of science has the potential to dim

and homogenise both the public perception of science, and scientists' understandings of their identity and craft.

2.3 The policy narrative of the knowledge economy in the UK

That the knowledge economy is an unavoidable and positive development is a position held by the governments of post-industrial economies across the world (Warhurst, 2008: 71). The OECD, the World Bank and European Community support this appraisal also (OECD, 2001; European Commission, 2004: 6; World Bank, 2002). The UK's advocacy of a knowledge-based economy is thus in keeping with the global trend.

The UK policy narrative of the knowledge economy has provided continuity from the late years of the conservative government led initially by Margaret Thatcher (1979-1997), through New Labour's administration (1997-2010) to the present Conservative-Liberal Democrat coalition government (2010-). The narrative has won the approval of UK business. For the most part, our discussion will examine the policy developed under the New Labour government, since it is under this administration that the knowledge economy rose to prominence on the political agenda. In 1999, Charles Leadbeater - reportedly former Prime Minister Tony Blair's 'favourite thinker' - revealed why New Labour must give the knowledge economy the utmost political attention.⁵

In the next century, the engine of growth will be the process through which the economy creates, applies and extracts value from knowledge.

(Leadbeater, in *Times Higher Education*, 1999)

2.3a Knowledge

In the UK policy narrative, knowledge and education are defined as economic commodities. This view is not entirely new; since the 1960s, politicians have tended to think of higher education in terms of its effect upon economic growth (Wolf, 2004: 316).

The election of Margaret Thatcher's Conservative party to government in May 1979 popularised an instrumental view of higher education (Greatrix in Bosetti and Walker, 2010: 6). Thatcherism was premised upon neoliberalism, and so promoted entrepreneurial individuals. The Thatcherite view was that individuals with higher education qualifications were more likely engage in entrepreneurial

⁵ Leadbeater is often referred to in this way, for example in his *Financial Times* profile, 2010.

activity, and so they supported the massification of higher education. The government also sought to improve technological literacy.⁶ The biggest change that the Conservatives made to higher education came in the form of the 1992 Further and Higher Education Act, which abolished the distinction between universities and polytechnic education colleges, the result being that each institution type would thereon bear the title of ‘university’. An explicit reference to the knowledge economy may not have been made at the time, but the rationale was clear, with a 1987 Department of Education and Skills report declaring that higher education should ‘*serve the economy more effectively*’ (Department of Education and Skills, 1987). The Act was a symbolic demonstration of the economic importance of the vocational curricula taught in former polytechnics. When New Labour acquired office in May 1997, they were bequeathed a mass system of higher education.

New Labour advanced a more sophisticated understanding of the relationship between knowledge, higher education and economic growth. Consumed by considerations of public image, the soundbite of the ‘*knowledge economy*’ was a catchy means of communicating the New Labour vision (Driver and Martell, 1999: 2). The knowledge economy quickly became a defining insignia of the New Labour government. With far greater openness than their predecessors, the 1998 White paper *Our Competitive Future* set out New Labour’s plans to realise a UK knowledge economy. In its foreword, Prime Minister Tony Blair asserted that ‘*enterprise, flexibility and innovation*’ were essential to the global economic competitiveness of the UK (Department of Trade and Industry, 1998). Especially noted was the role of ‘*science...enterprise [and]...creative partnerships*’ (Ibid.). From the outset, New Labour demonstrated strategic intent to foster a knowledge economy centered around commercially valuable techno-scientific knowledge.

The New Labour policy narrative stipulated that the commercial value of knowledge ought to be demonstrated (Rowland, 2006: 45). Consistent with Lyotard’s performativity principle, the economic value of knowledge would be ascertained through defined criteria. With the demise of ‘truth’ as a meaningful way to value knowledge; the performativity principle directs attention instead to efficiency and the best possible output in terms of profit and power. Knowledge is invested in for these reasons, and those stakeholders who invest - politicians, technocrats, bureaucrats and industrialists - demand the ‘*production of proof*’ that knowledge has indeed delivered the desired ends (Lyotard, [1979] 1984: 46). The Research Assessment Exercise (RAE) is

⁶ For example, 1982 was named ‘Information Technology Year’. The government provided every secondary school with a computer.

a prime example of performativity, since it measures intellectual quality by ‘proof’ of publication rates. The higher education philosopher Ronald Barnett is one of many critics of the RAE, arguing that quantity is prioritised over quality, and the matter of whether academics have an audience for their research is ignored (Barnett, 2000: 43). This latter point raises a question about efficiency of knowledge production, something that the current coalition have attempted to address, albeit in similarly ‘performative’ terms.

The Research Excellence Framework (REF) is set to replace RAE in 2014, and continues along the performative principle. This time however, assessments of peer-reviewed publications will be weighted alongside measurements of economic and social impact. The coalition government justify the REF by pointing out that it will allow greater accountability of public spending and learning from best practice, because the best value for money research endeavours will be made transparent (REF, 2012). The results of the REF will determine future funding allocations, meaning that institutions that perform well can look forward to a more secure financial future. Like the RAE, the REF is not without criticism from the scholarly community, most notably among HASS scholars, who fear that the methodology of the REF is biased against non-quantitative subjects, meaning that the economic and social benefits of their research will be difficult to demonstrate and therefore undervalued.⁷ The knowledge economy foundations built by New Labour have been largely unchallenged by the current coalition government; most certainly, the supremacy of techno-scientific knowledge is a clear thread of consistency in the UK policy narrative.

2.3b Human capital

For New Labour, the mass higher education system was in place to deliver the UK’s knowledge workers. At the 1999 party conference the then Prime Minister, Tony Blair, shared his ambition to see fifty per cent of all young adults enrolled in higher education. This target was recorded in the 2001 Labour Party manifesto and became a famous policy of the administration (Labour Party, 2001: 7). The fifty per cent quota was justified in economic terms; that highly-skilled human capital was necessary for economic growth, and that graduates would enjoy higher earnings and a lower chance of unemployment (Ibid.: 20).

⁷ This is evident in the attempt of the London School of Economics to guide HASS scholars through the REF procedure. The ‘Impact of Social Sciences’ project, launched in June 2011, aims to help HASS scholars prepare for the REF 2014, thereby ‘*maximising the impact of academic research*’ and protecting the HASS subjects from performing badly.

This expectation is now enshrined in UK higher education policy. Indeed, it has provided the current coalition government with a justification for passing an increasing portion of the cost of higher education to the student. In its opening pages, the 2010 Browne Review reveals to us the real point of higher education in contemporary Britain. For the individual, higher education matters because it is the key to their place in the knowledge economy and an elevated socio-economic standing:

Higher education matters because it transforms the lives of individuals. On graduating, graduates are more likely to be employed, more likely to enjoy higher wages and better job satisfaction, and more likely to find it easier to move from one job to the next.

(Browne, 2010: 14)

Policy-makers believe that the UK knowledge economy needs highly-skilled workers; the carrot with which future knowledge workers are tempted are the promises described above. There is little room for the ‘social’ in the language of current higher education policy; where it is used, it refers only to the ‘social mobility’ that an educated individual can expect to enjoy over the life-course, as they increase their earning capacity (Browne, 2010: 14). The majority of press attention leveled at the Browne Review focused upon the rise in tuition fees. The assumption of a ruthless individualism, that charges through the report, received far less coverage. By encouraging students to act as consumers, Browne has advanced the knowledge economy view of higher education to a greater extent than ever before in UK policy. Students are to think of their higher education as the purchasing of an economic investment; the objective of which is to reap the greatest financial reward. The aim of a university degree is no broader than this.

Policy makers have cleverly directed student expectations in such a way that they believe best serves the skills needs of the country. The independent Leitch Review of Skills, commissioned in 2004, analysed the UK’s long-term skills requirements. It reported in 2006, arguing that the UK’s future national economic prosperity depended upon a highly skilled workforce. This conclusion was the outcome of a comparative and future-facing perspective. On the basis of the skills growth rate in America, Japan, China and India, Leitch warned that the UK risked a considerably diminished share of the global wealth, unless it could guarantee the quality of its human capital (Leitch, 2006: 32). With a nod to the third way, Leitch further argued that increasing the number of highly skilled individuals in the UK would also lead to an enhanced quality of life and greater social justice (Ibid.:

27). The ‘*world-class skills*’ that Leitch had in mind implied mass participation in higher education and a commitment to life-long learning (Leitch: 1; 3). Not all skills were equal however; indeed the 1998 paper *Our Competitive Future* had already identified skills and knowledge in ‘*science and technology*’ to be of the most value in an economy driven by knowledge (DTI, 1998).

New Labour seemed certain of the UK’s future as a knowledge economy. In 2006, the year of Leitch’s publication, the government commissioned the London based consultancy *The Work Foundation* to deliver a detailed report on the UK knowledge economy. The paper confirmed that while access to energy and raw materials were still important to the UK economy; the presence of knowledge, and knowledge workers, stood at the heart of future economic competitiveness (Brinkley, 2006: 5). The knowledge economy was the present and the future; the term fast achieved a ‘*zeitgeisty*’ buzz amidst London policy circles (Barkham: 2008). The London based think-tank Demos welcomed New Labour’s position; its 1999 report *The Creative Age* put forward a passionate argument for the massification of higher education, grounded in the evidence that a growing number of UK jobs required creative input and analytic skills - qualities associated with post-school education (Bentley and Seltzer, 1999: 10).

The policy narrative was thus clear about what it wanted: knowledge workers with techno-scientific expertise and higher-education qualifications. Less clear however was whether this demand could be met. In 2001, the physicist Gareth Roberts was commissioned to answer this very question. Reporting in 2002, the Roberts Review painted a concerning picture of the quality of STEM skills in the UK. Two issues in the supply chain were identified as being of most significance. The first was the falling numbers of individuals studying STEM subjects. The second was the poor ability of STEM graduates to translate their knowledge to the world outside university (Roberts, 2002: iii; 29).

The problems that Roberts stumbled upon were not wholly new. The 1993 Conservative government White Paper, *Realising Our Potential: A strategy for Science, Engineering and Technology* argued that too many STEM PhD students lacked the appropriate skills to work in industry (Powell and Green, 2007: 91). STEM PhD students were flagged up as of particular concern by Roberts too. The report found that STEM PhD students’ aptitudes for communication, team-work, project management and business awareness were so inadequate that STEM employers often found it difficult to fill vacancies (Roberts: 29). Clearly, the STEM PhD model was failing to

produce human capital fit for the knowledge economy. Policy makers learnt that targets had to account for quality as well as quantity.

The Roberts review made several recommendations specific to the STEM PhD, many of which have directly affected the young scientists in this study. RCUK (Research Councils UK) funding was to be made conditional upon students completing two weeks of transferable skills training per academic year (Roberts: 11). The aim of transferable skills training is to address the skills deficit noted by the STEM employers surveyed in the review. Roberts also wanted to ensure that the brightest minds considered the STEM PhD, instead of pursuing more financially lucrative work immediately after their undergraduate degree (Roberts: 25). As a result, the STEM PhD stipend was raised to match the average graduate starting salary.⁸ Furthermore, it was recommended that payments ought to be made for three and a half years; the time it took most students to complete, in contrast to the traditional three year model (Roberts: 10,11). If we consider the situation for HASS PhD students over the same time period, the privileged position of techno-scientific knowledge in knowledge economy policy is markedly clear. In the HASS disciplines, PhD studentships have not increased and the teaching grant was cut by the coalition government in 2010. Collectively, these policies are likely to depress the supply and quality of future HASS researchers (Callender, 2010: 1).

Almost one decade on from the initial report, an independent review of the Roberts agenda judged transferable skills training to be only more important to the STEM PhD in 2010, and advised its continuation (RCUK, 2010: 7). The Roberts agenda found support in the European Union also; the 2005 ‘Salzburg Principles’ were established to reform the European doctorate. The Salzburg principles were part of the wider ‘Bologna Process’ – the policy to create a European Higher Education Area, within which the PhD degree would be standardised across Europe (European Universities Association, 2010). The Salzburg principles carry the same tune as Roberts; stating that PhD graduates must be trained to meet the *‘needs of an employment market that is wider than academia’* (Ibid.). The knowledge economy has not only shaped UK higher education policy; it has framed European thinking too. In addition, the UK business community wholeheartedly supported the changes to the STEM PhD. The 2008 Confederation of British Industry (CBI) report *Science and Society* detailed how the UK needed more STEM researchers, and how STEM graduates needed to be more business ready (CBI, 2008:1). The 2009 Council for Industry and Higher

⁸ The average graduate starting salary was stated to be £12,000 by the Roberts Review (Roberts, 2002: 10).

Education (CIHE) report *The Demand for STEM Graduates* concurred that employers needed STEM specialists above any other discipline (CIHE, 2009: 8). In business as well as the policy narrative, techno-scientific knowledge is prized above all.

The policy and business literature brims with enthusiasm over the especial value of STEM PhD graduates. We are told that STEM postgraduates contribute more greatly to innovation, leadership, entrepreneurship, management, and research and development (BIS, 2010: 8). Their expertise is required for specialist roles (CIHE, 2010: 10). Even in more general positions, PhD graduates are higher-quality candidates (CIHE, 2010: 12). Employers expect PhD graduates to bring superior business awareness, quantitative skills, language proficiency and numeracy (BIS, 2010: 6). As long as the PhD remains the primary method of training independent researchers in the UK, the business community will continue to look to its graduates as the architects of innovation (BIS, 2010: 5). Government and industry both have attempted to lure STEM PhD graduates into commercial research by pointing out the potential for high earnings (CIHE, 2009: 40; BIS, 2010: 5).

Knowledge economy policies have successively changed UK higher education, and consequently, the UK STEM PhD. This is hardly surprising; a PhD for the knowledge economy is not the same as a PhD for academia. In his 2007 study of the UK PhD, Chris Park concluded that the degree had been '*redefined*' (Park, 2007). Park had voiced concerns that some of the PhD's traditions faced erosion in a publication two years earlier. On a more positive note, however, he suggested that the degree had been made more accountable in light of an increased number of interested stakeholders (Park, 2005: 189). Political and commercial interest in the PhD meant that skills training, submission rates, supervision and examination outcomes were now scrutinised to a greater extent than before (Park, 2005: 202). Park did not foresee any reason why political and economic interest in the STEM PhD would diminish.

The STEM PhD is no longer a purely academic pursuit. STEM PhD students are encouraged to think of themselves in human capital terms: they are learning to earn, and their higher education is a costly financial investment. Often, this investment is made by the taxpayer or a private corporation, and so, STEM PhD graduates must demonstrate their added-value and deliver applied benefits for the nation (Park, 2007: 7-8). Powell and Green agree upon this point; highlighting how the public now expect a '*repayment*' from the doctorate (Powell and Green: 233). The public, politicians and businessmen all appear to have accepted the orthodoxy: that investment in STEM human capital

will deliver long-term economic competitiveness for the country. Less clear is how STEM PhD students view the policy narrative of the knowledge economy. Barnacle hypothesised that the economic and political weight bearing upon the STEM PhD student would enact a change in their perception of self and purpose (Barnacle, 2005: 187). The *raison d'être* of this thesis is to shed light on precisely this question.

2.3c Innovation

In addition to highly-skilled human capital, UK knowledge economy policy identifies innovation as a key ingredient for a prosperous knowledge-based economy. Innovation received much attention in the policy literature of New Labour. The Browne Review, approved by the current coalition government, tells us that, along with the production of human capital, innovation is a defining function of the contemporary British university. While most of the cost of higher education has shifted to the graduate; universities as institutions, and the research activities they pursue, remain worthy of public investment because they are a vital cog in the knowledge economy machinery. As Browne explains:

*Higher education matters because it drives innovation and economic transformation.
Higher education helps to produce economic growth, which in turn contributes to
national prosperity.*

(Browne, 2010: 14)

Higher education drives innovation, and innovation underlies economic growth. The latter part of this assertion - that innovation underlies economic growth - is an idea that New Labour spent a great deal of time and effort establishing. New Labour realised that if the UK wanted to build a globally competitive knowledge economy, then human capital on its own would not suffice. The UK must also produce innovative, knowledge-intensive products and services. Scholarly research supports this balanced take on the workings of a knowledge-based economy. As Brown, Lauder and Ashton pointed out, Western graduates are often too expensive for multinational knowledge firms, who can increasingly source suitably skilled labour in southeast Asia (Brown, Lauder and Ashton, 2008). If the UK planned to make money from knowledge and deliver the promise of highly-paid, interesting work for its graduates, then it would have to foster homegrown innovation (Ibid: 7). Failure to do so might prove to be a double-bind, because highly-skilled UK human capital may choose to find knowledge work overseas, taking their STEM-added value away from UK GDP.

New Labour made many promises in its innovation policy. There were several public commitments to the continued funding of basic research. A Social Policy Research Unit (SPRU) Report from 1996 proved to be very useful in providing the evidence for this position. The SPRU Report detailed the public benefits of basic research, and explained that the patenting problems caused by basic ‘knowledge spillover’ meant that private corporations could not be expected to make adequate investment (SPRU, 1996: vi). In 2004, the Department of Trade and Industry noted its obligations to ensure that UK researchers had access to high quality research facilities and sources of knowledge; conditions that required the financial underwriting of government (DTI, 2004: vii). SPRU had already suggested that providing the right conditions for innovation was a must; the most talented researchers need a fitting environment, and the sense that they are valued, in order to be motivated and inspired (SPRU: 34).

The 2007 *Sainsbury Review of Science and Innovation* showed how seriously New Labour took the innovation issue, and brought together yet more promises. The report concluded that improving the UK’s innovation performance demanded financial support from the state (Lord Sainsbury of Turville, 2007: 1). The financial promises made by New Labour included: tax credits for R&D activity; the creation of a business-led Technology Strategy Board (TSB) to advise on global economic innovation; a continued commitment to investment in R&D and knowledge transfer partnerships (KTPs); and, the facilitation of international research collaborations (Lord Sainsbury of Turville, 2007).

KTPs were highlighted as the means to realise networks of freely-flowing information and knowledge, so central to Manuel Castell’s thesis, as we saw earlier in this chapter. The establishment of the Science and Innovation Network (SIN) is further evidence of New Labour’s belief in the importance of knowledge networks. The aim of SIN, which continues to exist to this day, is to use the traditional methods of diplomacy to foster international scientific collaboration (FCO/BIS, 2010: 4). In 2010, the Minister of State for Universities and Science, David Willetts, approved the ongoing importance of SIN, explaining that while the UK ‘*punches above its weight*’ in many areas of scientific research, SIN enabled access to ‘*the best global scientific thinking*’, particularly in areas where the UK is not world-leading (FCO/BIS: 3). Willetts reminded us once again of why this was important: ‘*science and technology are major drivers and producers of economic growth*’ (Ibid.).

In 2008, one year after the Sainsbury Review, the publication of *Innovation Nation* indicated that New Labour's preoccupation with innovation policy showed no sign of receding. It announced that NESTA (the National Endowment for Science, Technology and the Arts), had been tasked with the development of an Innovation Index in order to measure the UK's innovation performance (DIUS, 2008: 7). During this time, the financial promises made by the government grew in magnitude. The report asserted that the UK would have to '*invest more strongly than in the past*' in order to nurture innovative activity (DIUS: 42). The 2009 *Annual Innovation Report* presented public assurances that investments in innovation paid off; it reported that for each £1 million spent on innovation activities by the Regional Development Agencies, £8 million was returned into the regional economy (BIS, 2009). It is noteworthy that even as the UK economy entered recession after 2008, financial support endured. Rather than turning UK policy-makers against the knowledge economy vision, economic slowdown appears to have convinced policy-makers that innovation is a cornerstone of the '*post-recession economy*' (Brinkley: 2009).

As noted in the Browne Review, universities have been cast as key drivers of economically-valuable innovation. This image of the university is traceable in New Labour's policy thinking; the 2003 Lambert Review proposed for business-university collaborations to be strengthened in the UK. The Review advised universities to become better at translating scientific research into intellectual property and financial profit. One way of doing so would be to open up their laboratories and research staff to the business community, and to work on industrial R&D projects (HM Treasury, 2003: 3,4). Universities were told to evolve to be more business-like; in particular, to lighten internal regulation which was seen to stifle innovation (HM Treasury 2003: 6). Pointedly, New Labour reallocated responsibility for universities to the Department for Business, Innovation and Skills (BIS), following a merger of the Department for Innovation, Skills and Universities (DIUS) and the Department for Business, Enterprise and Regulatory Reform (BERR) in June 2009.

The business community welcomed the policy stance. The CBI Report *Stronger Together* urged businesses and universities to '*align*' their interests (CBI, 2009: 7). It argued that by doing so, universities would enjoy greater control of their long-term financial security and autonomy, in a time of declining public resources (CBI: 6). Exemplary experiments followed; the now inactive i10 partnership (2003-09) joined universities in the east of England with local business, in order to work on science and technology-based projects. By 2009, the partnership claimed that the region

was home to the largest concentration of research engineers in the country, and that it spent three times the UK's average on R&D (AUEE, 2009). There are other examples too: the University of Cambridge hosts a research center funded by Unilever; the Engineering School at the University of Lincoln is part funded by Siemens. Interpreting institutional behaviour is not straightforward however. While it may seem as though the vision of Lambert has been dutifully followed by universities, one must question - in a time of retrenched state funding for universities - whether the practices of some universities ought to be taken less as a sign of ideological conscription, and more as an indication of astute pragmatism.

The coalition government has largely upheld New Labour's thinking on innovation, with little deviation from the main threads of the argument. The Conservative Party commissioned the entrepreneur James Dyson to conduct a study of innovation in the UK, and it concluded that university laboratories were essential hubs of innovation, especially if they combined blue-skies research with a commercial sensibility (Dyson, 2010: 5). If UK innovation needs entrepreneurial researchers, both inside and outside of the university, then it is understandable why policy makers are keen to see universities open their doors to business and politics, and become far more fluid organisations than in the past. In 2010, the Council for Science and Technology (CST) told university researchers to become better at exploiting their own ideas, and to *'[exploit] ideas from elsewhere, to harvest greater benefits from the economy'* (CST, 2010: 3). The vision has all the hallmarks of mode 2 knowledge: new thinking combined with existing knowledge to produce a novel, context-relevant solution.

Evidence suggests that the UK innovation policy is starting to pay-off. The number of spin-off companies set up by universities to exploit intellectual property grew steadily under New Labour and has continued to increase under the coalition government (Lawton-Smith, 2011). Within the first few months of office, the coalition sent a clear message that innovation remained a top priority. In the foreword to the report *Blueprint for technology*, published in November 2010, Prime Minister David Cameron stated:

This government believes technology-based innovation will be one of the key drivers of the economic growth that Britain so urgently needs.

(HM Government, 2010: i)

Seemingly true to their word, the science budget was one of the few protected areas in the 2010 public spending cuts announced by the government in its first term (HM Treasury, 2010: 6). While some commentators, such as Mark Henderson of the Wellcome Trust, lamented the point that a ring-fencing of spending is still a cut in real terms; science received favourable treatment when compared to the HASS disciplines, and the justification is economic, rather than a comment on inherent value.⁹

The coalition promised to follow New Labour's steps towards creating a '*high-tech future*' for the UK. It introduced an entrepreneur visa to allow individuals with a viable idea and supporting capital to set their business up in the UK. It claims to have created the '*most competitive tax system*' so as to entice global business to locate in the UK. Furthermore, it has reduced the burden of administration involved in setting up a business (HM Government, 2010: iv). These policies merge the neoliberal knowledge economy blend of entrepreneurialism bolstered by the state. On the one hand, the entrepreneurial individual is liberated from the bureaucracy of the state and high taxes. On the other, the state has committed £200 million of public money towards the building of Technology and Innovation Centers, wherein aspiring entrepreneurs can test new technologies, share research ideas, and garner support as they attempt to commercialise their inventions (HM Government: ix). Enhanced funding has also been promised for adult apprenticeships, particularly for individuals working in technology-based firms. Right throughout the innovation policies of New Labour and the present coalition, we can see that the assumption that techno-scientific knowledge underpins innovation and thus economic growth, has endured.

2.4 Conclusion

Part one of the critical literature review detailed how UK policy-makers, acting with the approval of a global neo-liberal consensus and the support of UK business, have distilled the rich theoretical legacy of the knowledge economy into an extremely precise definition. In the UK policy narrative, 'knowledge' refers to 'scientific knowledge', and 'economy' can be read as 'neoliberal capitalist economy'. The policy literature offers no explanation of why such a specific definition of the knowledge economy has come to dominate understandings; thus the viewpoint of policy-makers appears unjustifiably and arbitrarily narrow. The narrative was politically imposed, and it is no coincidence that its rise to prominence coincided with the inauguration of a newly-elected government in possession of a landslide electoral majority.

⁹ Comment made by Henderson at University of Cambridge Centre for Science and Policy Seminar, May 2012.

The policy narrative of the knowledge economy offers a restricted view of why we should value scientific knowledge, and how it converts into financial profit. The voices of theorists who prioritised tacit knowledge, knowledge management, and non-STEM knowledge appear to have been silenced. The performative regime, with its insistence upon a particular type of proof, now pervades institutions involved in knowledge production, and universities are no exception to this trend. With longstanding political support, the policy narrative of the knowledge economy has the potential to narrow and homogenise both scientists' and the public's understandings of the how and why of science. For the moment however, we must remember that, despite the power and prevalence of the knowledge economy narrative, it is not the only account of higher education and science. We shall now turn to look at some of the alternatives.

3. Beyond the knowledge economy: alternative accounts of the relationship between higher education, science and the economy

3.1 Introduction

In this second part of the critical literature review, I consider two alternative accounts of the relationship between higher education, science and the economy. The aim of this chapter is to contrast the contemporary dominance of the knowledge economy narrative of science with two other influential accounts of science: modernity and science studies. These accounts are normatively different to one another, and to the knowledge economy. The first account that I attend to is the narrative of modernity (3.2). The vision of modernity predates that of the knowledge economy, and we shall see later in the thesis that its normative musings continue to shape the thoughts and values of contemporary young scientists.

The second account I shall look to arises from the interdisciplinary research area known as ‘science studies’ (3.3). The starting point of science studies differs from the theories of the knowledge economy and modernity in that it sets out to deconstruct normative assumptions about science and reveal scientific practice as it actually happens. Nevertheless, from its deconstructive premise, the result of science studies is the construction of an image of science that runs counter to the suggestions of the knowledge economy and modernity. The ensuing discussion of these alternative accounts means that we can turn to the results chapters with greater enlightenment of the competing ideas that are likely to have influenced the normative constructions held by young scientists. By way of conclusion, the main differences between the three visions of science are summarised (table 3.1, p. 79), and the three emergent research questions are introduced.

3.2 The narrative of modernity

The modern period is often divided into ‘classical’ (1789-1900) and ‘late’ (1900-1989). In this section we will look at ideas arising from the whole period of modernity, and the argument will be made that many of these ideas continue to yield influence today. Modernity is an overarching theory of the physical and social world, it is important to note that in this literature review we will concentrate primarily on statements relevant to higher education and science. I will now discuss modernity, and the distinct elements that compose its worldview. A summary of our forthcoming discussion can be found in figure 3.1 (p. 57).

3.2a The rise of modernity

Modernity (1789-1989) signified a rupture with all that had defined the earlier Medieval period. It effected a transformation in ways of thinking and ways of doing. Implicit in such a grandiose statement of change was the suggestion of progress; a notion that endured as a guiding principle throughout the modern period. Belief that the modern way stood superior to the medieval way was, for the majority, unshakeable.¹⁰

Modernity operated on both philosophical and structural levels. Philosophically, it is associated with a move to liberalism, secularisation and the Enlightenment. The Enlightenment, perhaps the most famed cultural movement of the modern period, popularised rationalism and the scientific method. Rooted in a realist ontology, the Enlightenment posited a positivist theory of knowledge - that sense-data are the only reliable basis of knowledge - and claimed empiricism - experiments via formal scientific method - as the proper means for uncovering knowledge. Modernity thus attributed great authority to science: the capacity to speak truth to power. It is no coincidence that science grew at an unprecedented rate in the period of modernity; indeed, we can trace the beginnings of science as a profession to the early twentieth century (Shapin, 2008). On a structural level, modernity is associated with industrialisation, a move to capitalism and the rise of the nation-state. The modern world was one of optimism and growing confidence.

3.2b The modern university

The university came to prominence in the modern period, developing into the institution that we recognise today. The modern university purveyed a distinct account of the purposes of higher education, and conditions of knowledge creation, consistent with the overarching paradigm of the time.

In the 17th and 18th centuries, a turn towards a liberal model of education was already underway. The views of two influential contemporary social thinkers - John Locke (1632-1704) and Jean-Jacques Rousseau (1712-1778) had helped to steer popular opinion. Locke argued against vocational understandings of education; stating instead that the purpose of education was to nurture good judgement, rather than deliver specific technical skills. Rousseau similarly proclaimed the value of education in terms of individual development, rather than the delivery of preconceived

¹⁰ A minority of intellectuals did criticise the foundations and values of the modern project. We shall look at the anti-modern current later in this section (3.2e).

social and economic needs (Claydon, 1969: 124). Locke and Rousseau agreed that society had much to gain from the educated man; nonetheless, their respective contemplations begin with a concern for the individual.

The modern university was thus founded upon a liberal model of education. This meant that knowledge was valued for its intrinsic worth and that scientific knowledge production was a mark of national pride and progress. Fuller notes that in its early days, the Enlightenment was seen as an anti-university movement, since it accused the university of indoctrinating students through the transmission of hegemonic doctrines (Fuller, 2000: 61). In order for the university to flourish in modernity, it had to prove itself as an institution of liberalism and Reason, and it went on to do just that. The University of Berlin, inaugurated in 1810, is thought to typify the character of the modern university. Its founding visionary - the Prussian Minister of Education Wilhelm von Humboldt - built a model of higher education consistent with the principles of liberalism and the Enlightenment. The Humboldt-universität zu Berlin- renamed so in 1949 to honour its founder - was readily envied, and emulations soon sprung up across Europe and the West (Ash, 1997: 4). The cornerstones of Humboldt's model - knowledge creation for its own sake; the unification of teaching and research; a liberal curriculum; and academic freedom, became synonymous with the institution known as the university.

The Humboldt model promoted research-led teaching, although this idea can be traced back to the medieval university (Thornton, 2005). True to the modern vision, Humboldt saw knowledge as ever progressing, which meant that effective teaching had to be research-led. This principle was particularly influential in the rise of the British research-intensive universities, partially owing to the writings of the German philosopher Karl Jaspers (1883-1969). Jaspers enjoyed critical acclaim in Britain, and his 1923 work *The Idea of the University* restated Humboldt's emphasis upon uniting teaching and research. A third writer associated with the development of the modern university is John Henry Newman. It is often erroneously suggested that Newman prioritised teaching over research in the university.¹¹ This is not so; his work can seem to emphasise teaching at the expense of this research, but this tone has to be understood in the context of a heavily clerical Catholic Ireland, wherein Newman was merely trying to protect the principle of secular teaching as per Humboldt's model, and to ensure also that student rights were not neglected. In sum, the modern

¹¹ For example, this is the analysis of both Allen (1988) and Thornton (2005).

university was an institution of balance; it was neither school nor '*research institute*' (Ker, in Smith and Langslow, 1999: 14).

A further influential concept purveyed by the Humboldt model was that of *Bildung* (Ash, 1997: 9). *Bildung*, which has no equivalent in the English language, relates to emotional character. It is a state of personal and cultural maturation identifiable by open-mindedness and a willingness to learn from others. Achieving *Bildung* involved the critical analysis of knowledge claims, and sometimes, the rejection of beliefs once held to be true. It can be an uncomfortable process and is accordingly associated with higher learning. It is clear therefore, that despite the modern obsession with science and progress, Humboldt expected the university to produce a measured graduate able to safeguard the development of other aspects of human life. For Humboldt, science alone was judged insufficient to ensure desirable progress in the modern age.

We find further evidence for this judgement when we look at the curriculum of the modern university. Despite the fervour surrounding science and technology in the modern age, we can see that in the modern university, the significance attributed to the humanities is not diminished. It is important to note that in modernity, unlike today, higher education was not a mass pursuit. It was expected that most individuals would not attend university; and for those entering a technical career, an apprenticeship would suffice. The university was a seat of higher learning and the canons of academe were not for masses. The main disciplinary interests of the modern academy were science, literature and philosophy. This mix was seen as complementary though it was not expected that individual scholars would traverse disciplinary boundaries. In contradistinction to the mode 2 knowledge of the knowledge economy, the modern age is characterised by mode 1. Gibbons et al. share the view that the modern university taught and produced mode 1 knowledge - discipline-based; basic or applied; the work of individual researchers; and legitimised through peer review (Gibbons et al., 1994: 19; Heath, 2001). It is important to note that the chronology suggested by Gibbons has been disputed - notably by Fuller, and Etzkowitz and Leydesdorff - however, it is clear that the modern university organised knowledge along bounded disciplinary lines and that, in the writings of its architects - Humboldt, Newman and Jaspers - the ideal of mode 1 is certainly what they think the university ought to be concerned with.¹² Furthermore, it is the image that the modern

¹² Fuller suggests that the university has switched from mode 1 and mode 2 throughout its history (Fuller, 2000: 80 and 114). Etzkowitz and Leydesdorff argue that mode 2 knowledge preceded mode 1, since problem solving activities came before scientific theory (Etzkowitz and Leydesdorff, 2000: 116).

university created for itself, and in making the claim to be the rightful home of disciplinary knowledge, organised so as to complement the nature-society divide of modernity, the university protected its institutional autonomy (Etzkowitz and Leydesdorff, 2000).

Academic freedom was regarded as central to the modern university, and has persisted as a fundamental principle of western higher education. Humboldt believed that academic freedom was paramount to the success of a university. This meant freedom from the political regime of the day, and the excessive interference of private capital. Karl Jaspers felt especially charged to protect the Humboldtian ideal of institutional and academic freedom. *The Idea of the University* pictures the university as a community of scholars committed to the pursuit of truth. For success in this pursuit, Jaspers tells us that academic freedom is indispensable. He judged a limitation on academic freedom to be nothing less than a curtailment of human nature, because - as per the position of Aristotle - Jaspers proclaimed intellectual inquiry to be an intrinsic part of human nature (Jaspers, [1923] 1960: 42). Echoing Humboldt, and consistent with the rationalising tendencies of modernity, Jaspers' view was that academia's commitment to truth must stand above political allegiance (Ibid.: 145). Consequently, he was fearful of an excessive bureaucracy encroaching upon the university, since he thought that this would hinder academic brilliance.

Other modern commentators upheld the essential principle of academic freedom. For the political philosopher Anthony Arblaster, academic freedom implied the liberty of students and academics to freely follow their research interests (Arblaster, 1974: 15). The historian and liberal politician Conrad Russell viewed nationalist, religious and financial interests as highly corruptive to academic pursuits (Russell, 1993: 15). Louis Menand noted three assumptions that underlie the modern defence of academic freedom. The first is that the professional integrity of the university rests upon the integrity of its research. Demonstrating that research is undertaken and published without undue constraint is therefore critical to the professional integrity of the university (Menand, 1996: 8). The second is that academia must be a class-free pursuit, meaning that social, economic, political concerns must not have a directing influence over scholarly activity (Menand, 2001: 21). The third is that academic freedom benefits the nation-state. As Conrad Russell explained, though scholars sometimes cause trouble for the government by asking difficult questions; the long-term health of the political system undoubtedly benefits from the expertise of academia (Russell, 1993: 36). The contemporary popularity of evidence-based policy would seem to support this appraisal.

3.2c The modern doctorate

As the University of Berlin is generally considered to be the first expression of the modern university, it should not be surprising to learn that Germany led the development of the modern doctorate. Of course, it helped that a national culture of science was entrenched in modern Germany. The Kaiser Wilhelm Society, founded in 1911, presided over a network of independent scientific research institutes, meaning that scientific research was a viable and respected career. German university laboratories received generous investment, and attracted the most able scientists from across the world (Ben-David, 1971: 125). The German doctorate and the scientific community were sources of great national pride (Ibid.). Individuals were called to the German PhD on the sole basis of their research potential, identified by senior academics, and those selected could look forward to a life-long career in research. For most of the modern period, German science enjoyed a high degree of freedom. By the 1870s however, pressures for scientists to demonstrate the uses of their research were growing, and collaborations with industry, hospitals, and the military increased (Ben-David: 127). This was not seen as an overly problematic development from the perspective of the scientific community; with the continued protection of academic freedom, this shift further secured the standing of science as a propitious profession for the modern nation.

It was because of the usefulness of scientific research, and of the modern doctorate as the means to train scientists, that Britain and America became so interested in the German story. The translation of the German doctorate into British and American culture took time; and perhaps owed less to the potency of the Enlightenment narrative than it did to the promise of socio-economic benefit. As late as 1860, Britain and America possessed no meaningful counterparts to the research-led German university. By 1900 however, the American doctorate was attracting a growing number of students. The first British research degrees were introduced at Oxford in 1917 (Simpson, 1983).

Despite the American attempt to emulate Germany, in reality, their national situations could not have been more different. The scientific community in Germany was still relatively un-organised and centered around close-knit networks; namely, the relationships between promising student and established researcher. Possibly for reasons of national path-dependency, or in an attempt to make up for lost time, America decided to design a formal professional career path for young researchers. The American PhD originated in disciplinary areas considered to be of most relevance to society: agriculture; education; sociology; and later, nuclear research (Ben-David: 146). American scientific research output soon accelerated; the demand from prospective PhD students was high, and their

activities in the university departments – assisting with the teaching of undergraduates, for example - enabled senior researchers to devote more time than previously to research (Ben-David: 147). The American PhD experienced an additional boost from employers when it became recognised as a highly valued qualification (Ben-David: 155). PhD candidates received sponsorship from employers to research areas of mutual interest, although, consistent with the modern ideal, they were given great autonomy over how they pursued their work. While America departed somewhat from the German affinity with the Enlightenment, the modern principle of academic freedom enjoyed transatlantic significance in the modern period.

British academics traditionally spent very little formal time on research. University academics - Issac Newton included - were paid to teach, not to conduct research (Shapin, 2008). This situation altered in the modern period, as Britain looked enviously to the profits that Germany gleaned from its scientific research (Simpson, 1983). Favourable socio-economic conditions assisted this shift, as the value of the doctorate was increasingly realised. The first research degrees at Oxford arose through the backing of private finance: the Carnegie and Rhodes scholarships. Soon after, the British government realised that it would have to contribute too if a postgraduate research culture was to take off. In 1907, Prime Minister Arthur Balfour encouraged the setting up of the Association of Commonwealth Universities, eventually established in 1912, as a means to unify the scientific research efforts of the universities of the British Empire. The government's commitment to the funding of PhD degrees was consolidated at the UK Universities conference of May 18th 1917, in which individual institutions agreed to expand the provision of PhD studentships and postdoctoral research fellowships.

While American and British interest in the PhD and scientific research was certainly boosted by thoughts of technological advance and socio-economic benefit, academic freedom continued as a basic principle in academic life. While a new understanding of the usefulness of the PhD degree turned political opinions and garnered financial support, it is important to be clear that we are not discussing an instrumentalist view of the strength or sophistication that we see in the knowledge economy. Little theorising had been conducted on precisely how scientific research, and individuals with science doctorates, contributed to socio-economic progress. Modern scientists were largely left to get on with their research in an unfettered way, whether in university or industry, shielded by a banner of positivism and neutrality. As will shortly be discussed (3.2d), the scientist was a figure of

authority in modern times; earning society's trust by working neutrally at the margins of mainstream social, political and economic life.

The foundations of the UK PhD have changed little since its modern inception. Admission to the PhD is on the case of merit alone. It is expected that candidates will have demonstrated their academic ability in prior university studies. Their aptitude for research is particularly considered. Normally, applicants will have completed a Masters degree. PhDs can be full or part time; the former method of study taking approximately three years to complete. The written thesis is submitted to external examiners who are recognised experts in the candidate's field. The candidate is examined through the *viva voce*. This procedure serves to check that the submitted work is indeed the candidate's own; however, it also provides an opportunity for the thesis to be defended and discussed. The expectation is that the candidate will have answered a relevant research question and produced knowledge that is novel to their field. At the close of the viva, one of the following possible outcomes will ensue: outright pass; minor corrections; major corrections; re-submission for a lower degree; or, outright fail (Vitae, 2012).

These regulations have endured in the UK throughout the PhD's history, and they continue to inform the examination procedure that will face the young scientists of this study.¹³ That this model of the PhD has endured is intriguing; since, as we have seen, expectations of the purpose of doctoral students have undergone great change in the policy narrative of the knowledge economy. Freedom is reduced, private sponsorship abounds, and a career in academia is no longer the norm. We can discern a shift away from the modern focus on the PhD as the development of an intellectually sound thesis, in preparation for an academic career; to the contemporary, Roberts-led view of the PhD as a time for the development of higher skills that are equally suited to life outside academia (Roberts: 13).

3.2d The modern scientist

If modernity understood the natural world to be knowable through the scientific method, then it looked to scientists to communicate reality. Considered to be the source of truth and progress, science was revered in the modern period, and, as we have discussed, scientists were treated favourably at this time. Investment increased and scientific research became a recognised profession; but these changes did not occur at the expense of academic freedom.

¹³ As stated in the *University of London: Regulations for the Degrees of MPhil and PhD* (University of London: 2005).

Academic freedom was enshrined as indispensable to the scientific craft. Modern scientists defended their autonomy on the premise that scientific method - the source of truth - was a neutral undertaking. The integrity of science rested upon the idea that scientists were independent and spoke only truths about the natural and physical world. Modern science was, by necessity, divorced from social, political and economic concerns. Without academic freedom, scientists could not function properly; without the claim of neutrality, the scientific enterprise would lose its credibility. Modern society accepted, and supported, these cardinal principles of science.

The consequence of casting science as a neutral and value-free enterprise is that it made the modern scientist something of an invisible man. Of course, there were famed mavericks - but the majority of modern scientists viewed success as an impersonal contribution. Published results, and the facts that they generated, were neutral. The person was edited out of scientific life; and any indication that personality had a role to play in scientific discovery would be treated suspiciously, and as antithetical to Enlightenment principles. As Steven Shapin notes, by the mid nineteenth century, a '*crucial boundary*' was imagined to exist between personality and reason and method; with only reason and method seen as properly belonging to the creation of scientific knowledge (Shapin, 2008: 7). The principle of reliability - that all valid scientific truths ought to be replicated by any researcher following the same method - further eroded references to the individual person in modern science. It is important to note the consensus that encircled this model of scientific identity; for most of the modern age, it escaped serious contention.

Thus the modern scientist was something of a paradox: valued, trusted and authoritative; but treated by society as an invisible and neutral being. The moral agency of the scientist was certainly denied; as the late nineteenth century French mathematician Henri Poincaré mused:

Ethics and science have their own domains. They can never conflict since they never meet.

(Poincaré, cited in Shapin, 2008: 11)

The impact of modernity upon the identity of the scientist cannot be overstated. Prior to the postmodern turn, the disinterested, invisible scientist was entrusted with the credibility of modern science. Since then, we have experienced a shift from modern to knowledge economy science.

Today, scientific research converges with political, social and economic interests. Undoubtedly, this shift has implications for how we understand the integrity and authority of science. Crucially, as we will see later in the thesis, it has evinced a profound change in the way in which young scientists conceive of scientific identity.

3.2e The anti-modern current

It is important to acknowledge that even during its ascendancy, modernity was not without its critics. The anti-modern movement refuted the Enlightenment notion that universal truths could be uncovered through logic, reason and scientific method. The anti-modern movement was underpinned by an idealist ontology; a philosophical position that predates modernity, and is discussed in greater detail in chapter four, concerning the research methodology. Anti-modern thinking laid the foundations for the postmodern turn; before this, however, its impact was somewhat limited by the ongoing success of modernity. Nevertheless, it is important that we recognise the work of the anti-moderns; not least their concern over modernity's portrayal of the university.

The Hungarian sociologist Karl Mannheim (1893-1947) provides a good starting point for our consideration of anti-modern ideas, often collectively termed 'critical theory'. Contrary to the Enlightenment position, readily accepted by Humboldt, Mannheim emphasised the importance of the social and the subjective in the construction of knowledge. As a result, he deemed it nonsensical to suggest that the *raison d'être* of the university was the production of universal truths; for it was an impossible ambition. Mannheim concluded that the university ought to concern itself with the *deconstruction* of knowledge claims instead; in particular, in assessing the power basis behind the popular ideas and ideologies of society. Furthermore, since universal truths were a fallacy, Mannheim, echoing the work of Max Weber, judged knowledge claims to be relative. Modern science had made a great mis-judgement in suggesting that it was the sole legitimate producer of truth in society.

Jürgen Habermas was another authoritative critic of modernity. Specifically, he denounced the proposition that science stood for progress. Informed by Hegelian Marxism, Habermas, in a similar

vein to Mannheim, suggested that the university ought primarily to be a site of critique.¹⁴ Efforts ought not to be so focused upon the production of scientific knowledge, but instead towards the critical review of existing knowledge. Habermas believed that modernity would prove to be a short-term fashion, though his view was unpopular at a time when two world wars appeared to confirm the central importance of techno-scientific knowledge to the modern state. Nevertheless, Habermas viewed modernity as a naïve and shortsighted project, and was disappointed that the university should allow itself to be organised by modern principles (Habermas, [1985] 1989: 100). Furthermore, Habermas saw the claim of neutrality, made by modern science and the modern university, to be deeply problematic, since modernity was so evidently a narrative promoted globally by the governments of developed economies. This sentiment is continued in his nostalgic project to revive the ‘public sphere’: inclusive spaces wherein critical and informed public debate could occur (Habermas, [1962] 1992).

Habermas feared that the modern university would not cultivate individuals who possessed the necessary critical attributes in order to contribute to a thriving public sphere. Contrary to its assertions, Habermas believed that the modern university did not deal in truth, but instead uncritically and unthinkingly accepted the Enlightenment agenda. Hans-Georg Gadamer shared Habermas’ concern that students of the modern university lacked critical faculties. In *Truth and Method* ([1960] 1989), he argued that the modern university model was failing its students in terms of their capacity for analysis, instead instructing them to uncritically follow formal method. This is an issue that I will consider in chapter four, on methodology. In an earlier seminal text of the critical theory movement, *Dialectic of Enlightenment* (1944), Max Horkheimer and Theodor Adorno had similarly argued that modernity’s obsession with efficient processes and results was both uncritical and built upon a desire to serve capitalism, rather than uncovering truth in any meaningful sense (Horkheimer and Adorno, [1944] 1973: 8).

3.2f Reflections on modernity

Modernity endured as the dominant grand narrative for around two hundred years. It survived the criticism of the competing intellectual project of critical theory, and cast a lasting influence over our

¹⁴ Hegelian Marxism is concerned with the use of the *dialectical method* to uncover truths. Hegel pronounced the dialectical method to be a way of rationally assessing the adequacy of a social thesis; that is to say a thesis of man and the social world (Singer, 1983: 100). According to the dialectical method, a thesis would have to show itself to be rationally consistent and possess emancipatory potential.

conceptions of the nature and purpose of higher education and science. In figure 3.1, below, we can reflect upon the central tenets of the modern narrative.

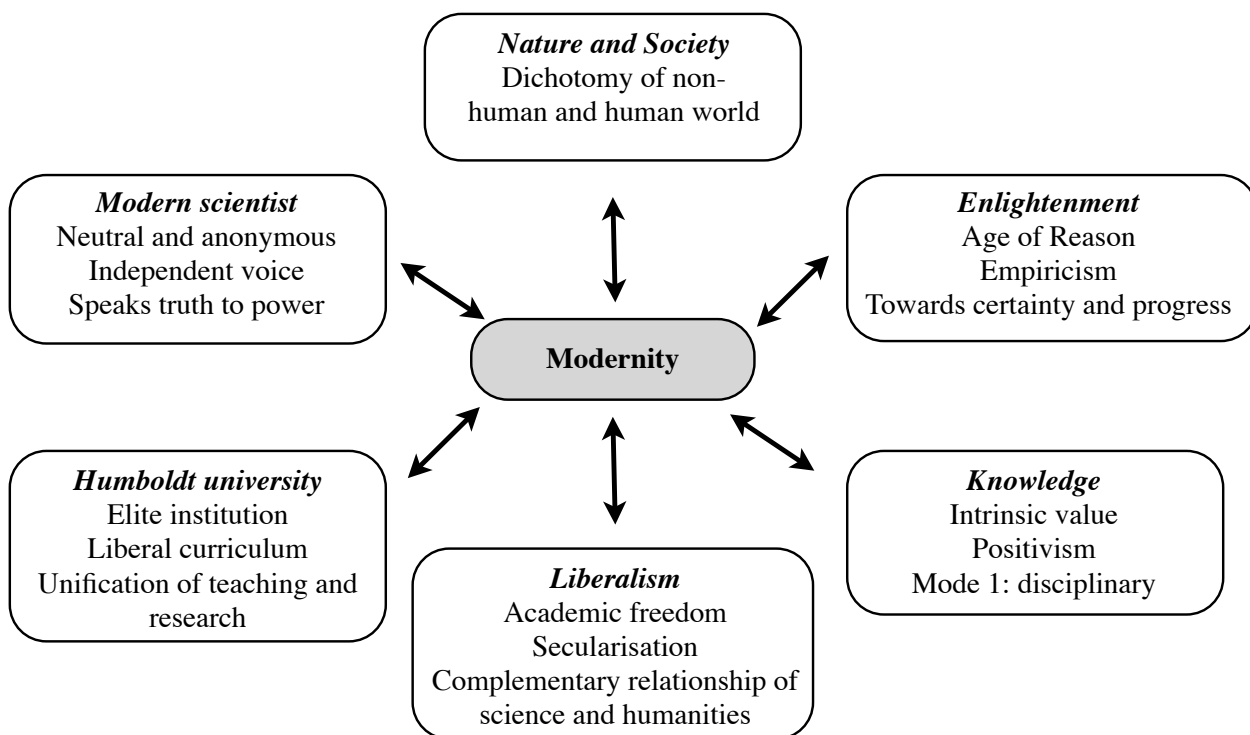


Figure 3.1 The narrative of modernity

As we reach the end of our consideration of modernity, we can discern a striking distinction between the position of modernity and that of the knowledge economy with regard to higher education and science. The question therefore arises of why the knowledge economy has come to the fore as a serious challenger to the modern system. The answer to this question is fully explored in chapter seven, but it suffices for our present purpose to say that the demise of modernity, and the modern university, owed ultimately to the postmodern turn.

The modern university was much attacked in the wake of the postmodern turn. Michel Foucault accused the modern university of engendering *'fractioned truths'*, and producing *'half-knowing'* individuals (Foucault, 1970: 323). Peter Scott reflected that postmodern critique exposed the modern university to be a *'fissiparous'* and unbalanced entity (Scott, 1991: 3). Jacques Derrida ventured a more positive outlook suggesting that postmodernism ought to be taken as a sign of the progress that modernity has so desired. In his essay *The Principle of Reason*, Derrida shares his hope that by strengthening the philosophy departments of universities, the institution could move

forward (Derrida, 1983: 18). In similar terms, Stephen Rowland suggested that depictions of the postmodern turn as a disaster for universities were misplaced; after all, postmodernity offered a more sophisticated epistemology than previously, and we had university scholars to thank for its inception (Rowland, 2006: 6). Certainly, the postmodern turn provided an opportunity, perhaps a necessity, for the university to reinvent its institutional character. The assertion of this thesis is that it did so primarily along the lines of the knowledge economy narrative. The implications of this shift in institutional identity for young scientists are critically considered in chapter seven.

In the later results chapters, we will see also that despite the shortcomings and eventual downfall of modernity, it continues to shape ideals about knowledge creation, higher education, science and the scientist. Academic freedom is tirelessly evoked when new higher education and research policies are proposed.¹⁵ In the UK, where change in higher education policy has been ceaseless for the past twenty years, romanticised portraits of the modern period are common; the image typically called upon is the era immediately after the Robbins Report, when resources flowed, jobs abounded, and universities commanded the respect of state and society (Smith and Webster, in Thorne, 1999: 23). This period resulted in the achievement of more Nobel Prizes by British academics than any other in the UK's history (Stephens, 1989: 34). Moreover, the unification of teaching and research has endured; as has the institutional autonomy of the university. The furore over the London School of Economics' alleged receipt of financial donations from the autocratic Libyan government in March 2011 is an example of the extent to which a university's reputation continues to rest upon its demonstrated distance from the state (for an example, see Mroz in *Times Higher Education*, 2011: 5). Citing the continued sanctity of institutional autonomy is furthermore one of the rather shrewd ways in which the current coalition government attempted to make the Browne Review, and its particular recommendation for less state and greater private funding of research, more palatable to UK universities.

3.3 The view from science studies

While the narratives of the knowledge economy and modernity may espouse different views on the nature and purpose of higher education and science, one characteristic that these narratives share is that both are premised upon normative assumptions. These narratives are, in short, ideological

¹⁵ For example, in letters to the *Times Higher Education* (3-9th February 2011 edition) corresponding academics argued against the government's imposition of a higher fee for undergraduate degree courses; against the government's proposed changes and 'one-size fits all' approach to the 'UK Professional Standards Framework for Teaching and Learning'; and against the government's intentions to concentrate research funding allocations to universities defined as excellent in certain field of research.

systems; they rest upon a particular worldview, represent specific interests, and attempt to construct an image of higher education and science that will best serve the realisation and continuation of the narrative.

The science studies view starts from an altogether different premise. It attempts to offer a critical, rather than a normative, view of the university and science. The intention of science studies scholars is to reveal scientific knowledge production, and the behaviour of scientific researchers, as they really are. Although science studies began within a *deconstructive* intent, it nonetheless delivers an image of science and the university that we can contrast with the constructs of modernity and the policy narrative of the knowledge economy. Science studies finds intellectual affinity with critical theory and postmodernism, introduced in the previous section. I will now discuss the rise of science studies, and its comments upon: the relationship between science and politics; the social construction of scientific knowledge; techno-scientific innovation; and, the scientist. The contents of this discussion are summarised in figure 3.3 (p. 77).

3.3a The emergence of science studies

Science studies is a broad, interdisciplinary area of scholarship. However, its deconstructive guise is a relatively new development. Throughout the twentieth century, what is now known as the 'Standard' or 'Received' view of science prevailed among the scientific community and those who studied it. This narrative, rooted in realism, asserted that: the natural world was real and objective, and that these characteristics could be more or less faithfully represented (Mulkay, 1979: 19). The Standard view led social science scholars to conclude that inquiry into whether social, political, economic, cognitive or subjective factors influenced science was unnecessary. The Standard view answer was that these factors had no bearing on the neutral institution of science, or on the research of the pure and impersonal scientist. Karl Mannheim gave much thought to the nature of scientific knowledge, and while he identified limitations in positivist epistemology, he came to the conclusion that sociology - which arose from a different epistemological tradition and '*intellectual domain*' - was an ill-fitting discipline for studies of science (Mulkay, 1979: 16). Some decades later, attitudes changed and the possibility of a sociology of science became an accepted idea. The sociologist Robert K. Merton studied the dynamics of scientific knowledge creation; producing a view of the scientific community that suggested its members behaved precisely as the Standard View would expect. Specifically, in 1942, Merton suggested that the scientific community was organised around the five norms of communalism, universalism, disinterestedness, originality and skepticism - or,

‘CUDOS’ (Merton, 1973). Somewhat ironically, the scientist was to profess commitment to these values in order to be considered appropriately value-free in their work.

The Standard view protected science from invasive sociological inquiry for most of the twentieth century. This began to change at the time of the postmodern turn. By the 1970s, glimpses of the disunity within the scientific community started to come to the surface. Ian Mitroff’s study of the Apollo moon scientists, published in 1974, presented a list ‘*counter-norms*’ that stood in contradistinction to Merton’s norms (Mitroff, 1974: 592). The counter-norms that Mitroff observed included *particularism* - defined as the social and psychological characteristics of the individual scientist - which undermined the norm of objective universalism; and *emotional commitment*, which stood in opposition to the norm of emotional neutrality. Regarding emotional commitment, Mitroff viewed it to be ‘*an instrumental condition for the achievement of rationality*’ (Mitroff: 592). Mitroff’s intention was to highlight the extent to which, for every Mertonian norm there existed a counter-norm; and that, consequently, scientific knowledge production ought to be explained in reference to both norms and counter-norms. Mitroff thus portrayed science as an inexorably human pursuit, characterised by ‘*sociological ambivalence*’; and, he argued, made all the more rational because of the causal influence of these very human ‘*counter-norms*’ (Ibid.: 579). Mitroff’s study justified further explorations of the social nature of science; which had hitherto been impeded by the success of Merton’s model and the overarching modern vision (Ibid.: 580).

Science studies scholars quickly busied themselves with questions regarding the complex system of self-fulfilling norms and the language devices that had prolonged the Standard view. The sociology of scientific knowledge (SSK) took on the inquiries avoided by Merton; principally, the question of how scientific beliefs are formed (Laudan, 1977: 197). SSK scholars thought Merton naïve for suggesting that scientific discoveries were largely independent of social factors (Laudan: 220). It is important to note that science studies scholars are often at odds with one another; though failure to present a united position is fairly typical in the critical theory tradition, for the same reasons that thinkers on the left of the political spectrum are frequently divided. When one starts from a critical, or deconstructionist position, consensus can seem like an arbitrary stopping point; antithetical even to the foundations of the intellectual project. Certainly, this seems to have been the case with SSK, whose scholars could not quite agree upon the role that the social had to play. References are often made to the ‘Strong’ and ‘Weak’ programmes of SSK; the Strong programme associated most readily with David Bloor and Barry Barnes at the University of Edinburgh - argued that the

construction of all scientific knowledge was a product of psychological, social and cultural influences. Weak programme scholars endeavored only to explain failed scientific theories in sociological terms. This is significant because, while the discussion we are about to begin will provide many more contrasting ideas about science than we have previously surveyed, it will also lack the intellectual wholeness of the policy narrative of the knowledge economy and that of modernity. Science studies inspires us to challenge these narratives and think differently about the relationship between science and the economy, but it does not proclaim to offer a universal solution.

The discussion that follows is divided thematically, and draws from a diversity of science studies scholars. We begin with literature on the political nature of science (3.3b); followed by considerations of the social construction of scientific knowledge (3.3c); the scientist (3.3d); before finally looking to the science studies view on innovation (3.3e).

3.3b Political science

One of the most prevalent themes of science studies is the assertion that science is political. Simply put, the image of science as a neutral institution is fundamentally challenged. This suspicion is not wholly new; it can be discerned in Nietzsche's 1887 polemic *On the genealogy of morals*. In the final section of this work, Nietzsche argues that far from being an alternative to religion, science had come to replace it.

Nietzsche suggested that the worship of God had been supplemented by the worship of truth. Nietzsche viewed religion and science as examples of *aesthetic ideals*. Aesthetic ideals provide a goal for man, and human behaviour is organised in respect to this goal; but the problem with aesthetic ideals, according to Nietzsche, is that they take man further away from truth and liberty (Nietzsche, [1887] 1969: 155-6). Nietzsche treated the modern values of certainty and progress as mere myths; for science to be effective, Nietzsche believed that it must embrace the discontinuity and uncertainty that define the human condition. In other words, the pretense of modern science betrayed the reality of human existence:

All science... has, at present, the object of dissuading Man from his former respect for himself.

(Nietzsche: 155-6)

For Nietzsche, science was a dogma intent on reducing and simplifying human understanding. In a similar vein, science studies scholars have questioned the legitimacy of science's claim to represent a higher body of knowledge. In terms of science's relationship to society and the economy, science studies scholars tend to argue that science is rendered political because of interfering agents with political interests (Cozzens, 1990: 164). Karl Mannheim is one advocate of this view; explaining the 17th and 18th century growth of science in terms of the support of the bourgeoisie, who believed that techno-scientific knowledge production would aid the realisation of their politico-economic agenda (Mannheim [1952] cited in Mulkay: 13). According to this outlook, the objectivity of science may not necessarily be compromised; it is dependent upon how much academic freedom the scientific researcher continues to enjoy. If interested political agents are happy to work with the fruits of independent scientific research, and do not try to influence the process of knowledge creation itself, then it is possible to argue that the neutrality of science is not affected in such a relationship. The reality however is that interested political agents may try to steer the research agenda at a point further upstream in the process of knowledge creation, thereby stripping the entire research stream of its claim to independence. The scientific community is portrayed as the passive recipient of external ambitions; the consequence of its compliance with the agendas of others being that its traditional source of credibility is trampled upon.

There is a second way in which science studies scholars viewed science to be political, and this interpretation most certainly undermines the scientific community's assertion of neutrality. This interpretation implies that science itself conceals an inherent and proactive political position thereby making the notion of objective and neutral science wholly redundant. The independent voice of science is revealed as something of a fallacy; a clever rhetorical device employed by the scientific community to cocoon itself from unwanted social, political or economic pressure. While this reading may rob science of the authority that the moderns awarded it - namely, its assertion to speak truth to power - it empowers science in a different way, suggesting that scientists have as much influence as political and other interested agents in cultivating the relationship they share with the non-scientific world.

The literature on the second interpretation of political science is convincing. It has been suggested that the narrative of the objective and independent nature of science is, conversely, a political one. The sociologist Michael Mulkay came to this conclusion after examining the status of science in the political context of America in the 19th and 20th centuries. According to Mulkay, science has two

'cultural reservoirs' to draw upon when devising a political agenda favourable to its development (Mulkay: 98). The first cultural reservoir is the independence of the scientific community. The second is the comparative position of wider society; which is judged to lack the necessary expertise needed to seriously challenge scientific knowledge. In order to guarantee state funding, Mulkay argued that American scientists cultivated theories, drawing from both cultural reservoirs, that point to the politically untouchable image of science. From the first reservoir, the explanation was given that science must be distinct from societal interest in order to function properly, and so it must be supported as an independent community. From the second reservoir, we can see that science faced no real threat from other individuals and organisations in society with regard to the potential value of scientific knowledge. Scientists knew best, and scientific knowledge was best for societal development (Mulkay: 112). In the case of America, Mulkay observed that the principles of democracy were drawn upon also; because scientists could claim that their emphasis upon rational thinking together with a denunciation of knowledge based upon prejudice were ideal forces for a democratic society (Ibid.).

Joseph Ben-David agreed that the modern norms of science were used by the scientific community in order to assure a politically favourable position. Ben-David examined the growth of university-industry relationships in post-war America. As we saw earlier in this chapter, he noted that scientific researchers within industry were awarded considerable autonomy to pursue their research interests (Ben-David, 1971: 159). This can be explained in terms of the respect that industry of that time held for the autonomy of science, and the belief that over-directed research would fail to produce the best knowledge, for it would destroy the creative spirit of scientific research (Ben-David: 156). In other words, if industry wanted to invest in scientific research, it must ensure that the proper conditions for scientific knowledge creation were respected; otherwise, the whole effort would prove to be a wasted one. With this joint blessing of freedom coupled with funding, the American scientific community could observe that funding in the US for '*all kinds of research*' far exceeded that being offered to scientists in Western Europe at the time (Ben-David: 163). Scientists were happy to co-promote the message of the socio-economic uses of their craft, so long as their autonomy was protected.

Bruno Latour named this political behavior of science as '*black boxing*' (Latour, 1987: 131). In his work *Science in Action* (1987), far from being disinterested individuals, Latour portrayed scientists as entrepreneurs who chased scientific, political and economic goals (Ibid.). Latour claimed that

scientists achieved their goals by black boxing; so to say, by obscuring the truthful inner working of science within an inscrutable black box, which becomes more complex over time, until it is presented to society as a fact or technical artifact. Society, which lacks the means to open the box or to understand its contents, accepts the narrative of independence and authoritative expertise, presented alongside the resultant scientific object. Once the black box is constructed, non-scientists are dependent on scientific experts to make intelligible the nature and potential application of scientific knowledge. In order to keep political and financial sponsors on side, scientific researchers must thus be adept at communicating science in an attractive way. Latour calls this expedient process '*translation*', wherein the scientist simplifies information about the scientific community and its work in such a way that difficult questions will not be asked, and furthermore convinces interested stakeholders that a particular direction of research or scientific finding, complements their agenda. It is a means of convincing stakeholders who, with no knowledge of the inner workings of science, have to trust what scientists say. In translation, what the scientific community will typically say is that the interests of science complement those of stakeholders, and that the results of science deliver the solutions that stakeholders desire (Kendall and Wickham: 77). The sorts of interests that might converge in the process of translation might involve choosing how to solve a particular problem or funding research with the aim of bringing a particular product to the market.

The analyses of Mulkay, Ben-David and Latour suggest that longstanding socio-economic support for science is attributable to the willingness of the scientific community to play the political game. If political science equates to survival, it is therefore a behaviour that we would not expect the scientific community to abandon. How then, might we explain the more recent trend of knowledge economy policies as something that the scientific community is complicit in developing? Merle Jacob proposes that academic scientists are as much '*promoters*' of the knowledge economy narrative as they are '*victims*' (Jacob, 2003: 125). Jacob argues that scientists in the university have embraced the attitude of knowledge commodification; forging collaborations with industry, actively patenting research outcomes, and setting up spin-off companies (Ibid.: 138). The steady rise of university research management teams and knowledge transfer partnership offices, composed of the type of knowledge managers identified by Peter Drucker, would seem to suggest that UK universities have happily accepted the policies of the knowledge economy. Nevertheless, university scientists may well be the ultimate '*victims*' of this trend, Jacob warns, if the '*pre-condition*' of academic freedom is undermined (Jacob: 140). Many UK science-focused institutions however,

seem to have reveled in the casting of STEM knowledge as especially profitable. The institution featured in this study is not alone in highlighting its high-value contribution to society and the economy, and of the comparatively high earning potential of its graduates.¹⁶ Thus the suggestion that the scientific community has encouraged its co-option into the knowledge economy carries resonance.

Starting from the shared viewpoint of science as a political activity, Bruno Latour and Michel Callon developed the model of actor-network theory (ANT) to theorise how science policy is made. ANT proposes that science policy is socially constructed and politically negotiated; it is a meeting place for competing interests, amidst scientific facts and artifacts. In ANT, causal efficacy is granted to all involved agents; including scientific knowledge. In the realm of science policy, ANT rejects the deterministic implication that economic and political capital direct the conditions and activity of science (Kendall and Wickham, 1999: 110). Conversely, ANT assumes that science, technology, politics, economics and the public are mutually-shaping in the dynamic process of policy formation. Thus scientists may push policy in a certain way, but at the same time, scientists may take part in public engagement or follow certain political or industrial wishes in order to secure funding. All agents possess interests and all agents possess a degree of power within the equation; the end policy being the result of an expedient negotiation of interests and the exertion of power where possible.

Latour's earlier work on black-boxing adds to the theoretical appeal of ANT and suggests that it should not be assumed that scientists are poor politicians, meekly following the wishes of policy-makers and businessmen. A preliminary ANT analysis of UK knowledge economy policies reveals to us that the notion of negotiated interests may have some weight. It is notable that the knowledge economy endures as a promoting narrative for science at a time of austere public spending; it has legitimated the ring-fencing of scarce public funding for science, and also, a greater involvement of private industry. Given the present economic climate, these outcomes for the scientific community can be considered impressive, and do suggest that scientists are politically astute when they need to be.¹⁷

¹⁶ These statements can be found in the institution's mission strategy 2010-14.

¹⁷ It could be argued that Science is Vital, the grassroots lobbying body mentioned in the introduction to this thesis, provides compelling evidence for this appraisal. Its campaign against a cut to the science budget in 2010 repeatedly asserted the financial contribution of science to the UK economy; stating that any such cut would slow down economic growth in the long-term.

Closer inspection of how scientists work with one another has led some science studies scholars to conclude that scientists are highly political agents even when working within the scientific world. Thomas Gieryn coined the term '*boundary work*' in 1983, to describe how disciplinary boundaries, demarcating science from non-scientific disciplines, are constructed. Gieryn portrayed boundary work as an inherently political process; disciplines were viewed as protected spaces within which claims of intellectual expertise could be made, and authority thus established, without the interference of outsiders (Gieryn, 1983: 781). Boundary work reveals scientists as agents who are extremely aware of the social world around them but who actively construct a border between science and society. Furthermore, Gieryn's analysis suggests that scientists are adept at negotiation; since he explains the development of individual scientific disciplines in terms of political compromise and the common goal of protecting science from the excessive input of vested interests (Gieryn: 792).

Support for Gieryn's analysis can be seen in Pierre Bourdieu's depiction of how scientists interact with one another. Here too, the relationship that scientists share with one another and their discipline is deemed to be political in nature. According to Bourdieu, individual scientists who long for scientific success have to deploy a careful career strategy, characterised by political maneuvering. Young scientists must support the work of their peers and strive to gain their approval, in order to accumulate '*scientific capital*' (Bourdieu, 1975). In other words, they are expected to contribute to the current paradigm of 'normal' science (Ibid.).¹⁸ Only when a scientific researcher has accrued sufficient scientific capital, after years of positive results and publications, can they think of challenging the current orthodox paradigm. Thus, for Bourdieu, the career trajectory of the individual scientist, and the rate of general scientific progress, can be explained in terms of a succession of careful political calculations.

From science studies we therefore see various pieces of evidence pointing to the political nature of science. This challenges the assumption of many knowledge economy theorists and policy-makers that science can simply be subjugated and co-opted into their total vision. It may also be incorrect to assume, as Olssen and Peters do (2005: 314), that the knowledge economy is an imposed political discourse. The science studies literature encourages us to take seriously the notion that science may have played a part in the evolution and current ascendancy of the knowledge economy narrative. In

¹⁸ This terminology is taken from Kuhn's thesis of scientific revolutions, which we will look at later in this chapter (3.3c).

light of the postmodern turn, and its potential to damage the legitimacy of the scientific community, this interpretation is appealing; it makes sense that the scientific community would seek a grand narrative, with a force of persuasion akin to modernity, which espoused its importance for the progress of humanity. Moreover, science studies casts doubts over the historic claim of the economic, social and political isolation of science; a claim central to the narrative of modernity.

3.3c *The social construction of scientific knowledge*

Moving on from the many ways in which science may be considered a political activity, we will now explore how scientific knowledge is created; an issue of longstanding interest for science studies scholars. As we have seen, Bourdieu made the suggestion that consensus formation - a hallmark of modern science - was in fact the result of a socio-political process, and was not, as per the modern narrative, explainable in terms of the discovery of irrefutable universal truths. The prolific science studies scholars Bruno Latour, Steve Woolgar, Michel Callon, and Karin Knorr-Cetina have also dedicated much effort to promoting the view that scientific knowledge is, at least in part, *socially constructed* (Longino, 2002: 11).

We now know that Bourdieu theorised the professional behavior of individual scientists in terms of the desire to gain 'scientific capital'; so to say, the respect of peers, leading to a reputation of expertise, and finally, the more tangible rewards of autonomy, funding, and tenure that are associated with being a recognised authority. Knorr-Cetina categorised such explanations of scientist behaviour, and the scientific knowledge that results from this process, as '*quasi-economic*' (Knorr-Cetina, 1981: 70). In using this term, Knorr-Cetina wished to illustrate the extent to which the dynamics of Bourdieu's system mirror an economic market, replacing the pursuit and exchange of economic capital with scientific capital (Ibid.).¹⁹ Furthermore, Knorr-Cetina did not view Bourdieu's model as entirely novel. She discerned the use of an economic metaphor in Robert K. Merton's work, wherein the competition for scientific capital is likened to a financial marketplace, and in the work of Storer (1966), where the need to create new scientific knowledge is compared to the demand for new goods in the marketplace.

One of the most detailed analogies of science and capitalism can be found in Bruno Latour and Steve Woolgar's *Laboratory Life: the social construction of scientific facts* (1979). This study is an

¹⁹ This is not to suggest that economic considerations were absent from the pursuit of scientific capital. As Bourdieu (1975) noted, scientific capital could be transformed into economic capital; for example, by using one's scientific credibility to obtain research funding or an increased salary.

anthropological work, based on observations of neurobiologist Roger Guillemin's biology laboratory at the Salk Institute in California. Latour and Woolgar focused upon the way in which the day-to-day activities of the laboratory impacted upon the construction of scientific theory. For Latour and Woolgar, the whole scientific enterprise rested upon the modern consensus; that of an *a priori* belief in universal truth, and the unique ability of the scientific method to communicate it (Latour and Woolgar, [1979] 1986: 70). Latour and Woolgar conversely proposed that social factors, rather than universal truths and the common values of the scientific community, held scientific consensus together. Latour and Woolgar identified specific social norms, and claimed that these norms were entrenched in all aspects of scientific life. For example, Latour and Woolgar observed the process of writing a scientific paper, the purpose of which is to convince its readers that the evidence amounts to scientific fact. Latour and Woolgar noted how once a fact is accepted, all traces of the specific environment of the laboratory in which it was constructed are removed (Ibid.: 175). Great emphasis is placed upon writing a methodology to detail the legitimacy of how the fact was 'discovered', and in order to allow other researchers to, in theory, replicate the results following the same method. Nonetheless, while reporting of the controlled environment of the laboratory is prominent at the time of introducing the fact, by the time that the fact is accepted, all references to method, researchers, the geography and institutional affiliation of the laboratory and so forth, cease (Ibid.: 176). Thus we have a fact that appears to exist independently of the social processes that brought it to the fore, and we are convinced of the universal and non-social nature of the scientific fact.

Latour and Woolgar equated the construction and dissemination of scientific facts as a '*religious ritual*' or literary sophistry (Latour and Woolgar: 75-6). Individual scientists are seen to adhere to similarly rigorous and meticulously ordered social processes as they attempt to secure their place in the scientific community. Latour and Woolgar posited that scientific recognition is achieved through the successful production of scientific facts, in the manner just detailed. In most cases, and most certainly early on in a scientist's career, recognition is derived through affirming and elaborating the current scientific consensus; in other words, by publishing positive results in journals with a high citation index; not by publishing negative results in less orthodox titles. This process demands continual re-investment from scientists; scientists exist in a state of constant, global competition with one another, until an individual may claim the higher ground of expertise, demonstrable through their publication record. The costs of pursuing a fact or theory that upsets the current consensus are prohibitively high (Ibid.: 187). For Latour and Woolgar, the perennial strive for

scientific capital means that fact construction cannot be seen as matter of truth discovery, but rather, as a socio-political process dependent upon the ambitions of individuals and the social rules of science. According to Knorr-Cetina it is a dynamic of production for the sake of reproduction - so to say constructing facts purely to uphold the current paradigm - which reveals science to be, in part, a capitalist system (Knorr-Cetina, 1981: 73).

Nevertheless, Knorr-Cetina was not entirely convinced that the pattern of scientific knowledge production could be wholly explained with reference to capitalism. While she accepted some elements of the comparison, Knorr-Cetina argued that the construction of scientific knowledge was far more complex in practice. Knorr-Cetina located the social construction of scientific knowledge within a site that she termed '*transscientific fields*' (Knorr-Cetina, 1981: 81). Within the transscientific field, several factors will impact on knowledge production; and the desire for scientific capital is but one. Knorr-Cetina suggested a more comprehensive list of influencing factors to include: cognitive and disciplinary affiliations; the physical setting of the laboratory and the available apparatus or technical facilities; scientific and economic capital; and, agents outside the immediate site of knowledge production - whether they are figures from politics, business or the public (Ibid.). Transscientific fields are furthermore variable; so to say that the precise cocktail of influencing factors, and the relative influence of individual factors is contingent and subject to change at each site of scientific knowledge production (Knorr-Cetina: 83). Far from being universal, neutral and replicable, scientific knowledge production is proposed to be a complex and incidental process, in which many non-scientific factors collide to exert a shaping influence (Ibid.: 85).

The judgement of science studies scholars therefore is that social and non-scientific factors influence the construction of scientific knowledge, to the extent that scientific knowledge creation can be viewed as a political and social process. Funding and related economic issues also play an influential role. This view has consequences for how seriously we can treat the appropriateness of modernity as a normative model for science, but it also raises the question of whether the imposition of social, political and economic interests upon the scientific community is anything new. This latter point may temper the claims of scholars introduced earlier in the literature review, who through use of concepts such as academic freedom, academic capitalism and marketisation, attempt to warn us that the knowledge economy threatens the historic and proper status of science and the university. Science studies scholars suggest to us that the knowledge economy may be

simply a more explicit and extreme form of what has gone on for centuries, and that portrayals of knowledge economy policies being imposed upon passive scientists are far wide of the mark.

3.3d Techno-scientific innovation

The science studies view of techno-scientific innovation differs from the knowledge economy policy view in two major respects. First, science studies scholars conjure a non-linear and lengthier time-scale with regard to the relationship between the creation of scientific knowledge and the realisation of an innovative output. The second point stems from this, since it suggests that the rate of techno-scientific innovations does not necessarily correlate with the level of investment in scientific knowledge production. These points of difference are significant, since it may be the case that knowledge economy policies designed to stimulate innovation through investment are likely to lead to disappointment over lengthy waiting times, or outright failure.

The below quote from Foucault relays the postmodern, science studies view of innovation.

Knowledge is not made for understanding: knowledge is for cutting.

(Foucault, 1986: 88)

In this statement, Foucault means that the simple accumulation of knowledge lacks critical power. Foucault is not concerned with ‘know-how’, but with ‘know-why’; and he proposes that knowledge which most advances our answers to know-why questions, is that which boldly challenges the prevalent orthodox narratives of the day. For an example relevant to this literature review, Foucault would dismiss the modern definition of knowledge as aspiring towards understanding and certainty as something of a fallacy; it may contribute to the modern worldview but it does not take man closer to truth in any meaningful sense. Postmodernism arrived as a theory of knowledge that cut away at the unity of the modern order; it demanded that man must break his allegiance with other schools of thought, and embrace the endless uncertainty, albeit altogether more truthful position, of postmodernism. Foucault’s use of the word ‘cut’ is purposeful; he wishes to take us away from holism, and to realise that conflict and fragmentation ought to be welcomed as the rightful and inevitable conditions of human knowledge and existence.

Knowledge economy policy-makers view scientific innovation in terms of the profitable application of knowledge; science studies scholars recognise scientific innovation in terms of ‘*knowledge for*

cutting'. Clearly, the knowledge economy view of scientific progress, and the science studies view of scientific progress, are very different. What is concerning however, is knowledge economy policy-makers' apparent ignorance of, or lack of regard for, the account of scientific innovation that science studies scholars advance. Knowledge economy policy makers suggest a positive linear correlation exists between investment in scientific knowledge and innovative output. In contrast, science studies scholars offer a protracted and turbulent image of scientific progress. A visualisation of the discrepancy between these two versions of scientific innovation is shown on figure 3.2 below.

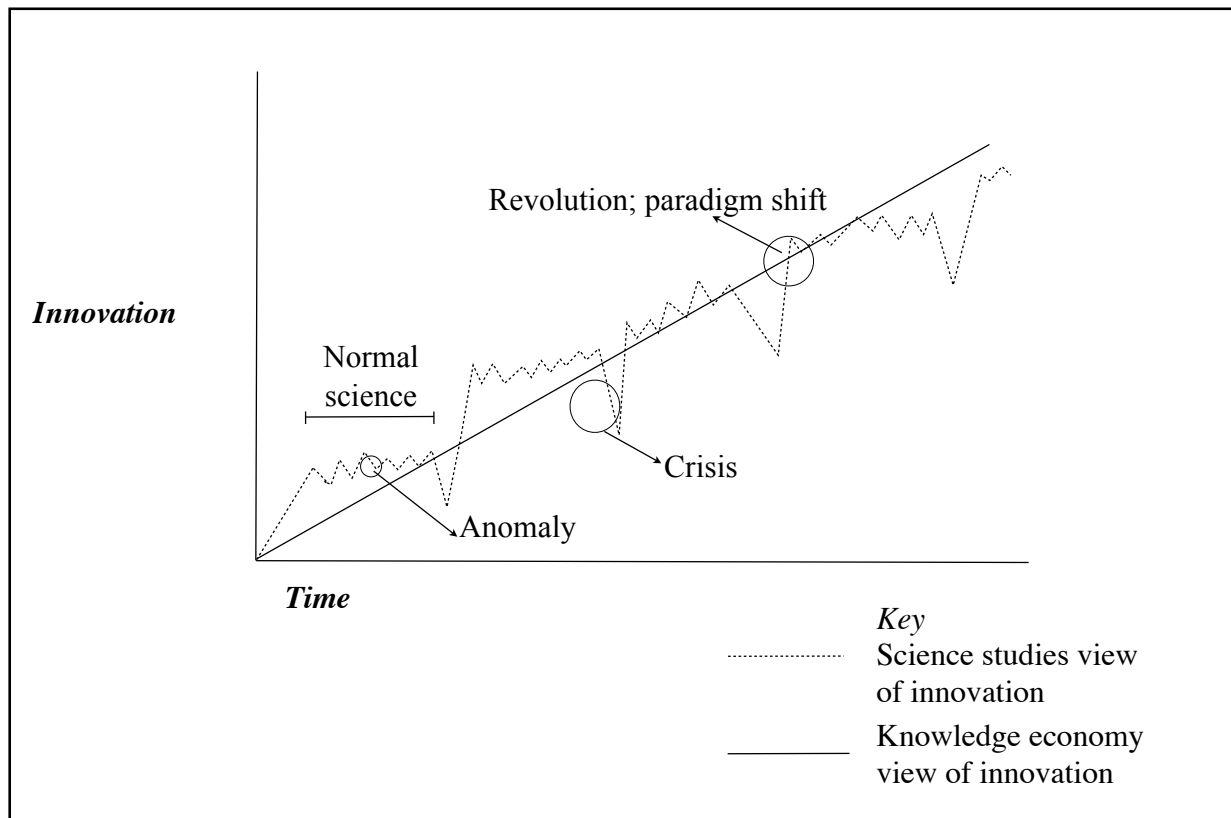


Figure 3.2 Two views of techno-scientific innovation

In figure 3.2, we can see the contrast between the linear upwards march of the knowledge economy view of innovation, and the less predictable view of innovation suggested by science studies scholars. The science studies view of innovation owes mostly to Thomas Kuhn, and his theory of the *Structure of scientific revolutions*. As Ian Hacking notes in his introduction to the 2012 edition of *Structure*, when Kuhn thought about advances in science, he thought primarily about *theoretical* advances; not the instrumental advances - from which technologies may derive - that are of interest

to knowledge economy stakeholders (Hacking, in Kuhn [1962] 2012: xvii).²⁰ Right away then, we have a tension: science is geared towards theoretical revolution; the knowledge economy wants science to focus upon *'technologies and cures, the novelties [of which]...are usually not theoretical at all'* (Ibid). Therefore a value question arises: the innovation that matters to knowledge economy stakeholders may matter very little to scientists and historians of science.

The difference between Kuhn's model of scientific revolutions, and the knowledge economy view of innovation, is more than just a matter of values. Kuhn's thesis is that science progresses in terms of successive revolutions, and that these revolutions have a structure. Most of the time scientific activity occurs during a phase known as *'normal science'*, during which, the scientific community forms a consensus over a particular worldview - as argued by Kuhn in his forerunner to *Structure, The Essential Tension* (Kuhn, 1979: 237). Kuhn referred to the consensus-prompting worldview of normal science as its *'paradigm'* (Kuhn, [1962] 1996: 23). During normal science, scientists strive to uphold the prevailing paradigm, preoccupying themselves with what Kuhn calls *'puzzle-solving'* (Ibid: 38). Reflecting on normal science, Kuhn remarked:

Perhaps the most striking feature of the normal research problems... is how little they aim to produce major novelties, conceptual or phenomenal.

(Kuhn, [1962] 1996: 35)

This is not to say that useful and commercially valuable knowledge do not emerge during periods of normal science. However, according to Kuhn, this is not the preoccupation of scientists. Scientific activity in these normal phases, is geared towards perfecting, or *'articulating'* theory to complement the normal paradigm. Scientific revolutions occur when there are too many anomalies that undermine the normal paradigm; after a period of crisis, a new paradigm is forged. The gravitas of Kuhn's model of scientific revolutions endures, despite his admission that it did not fall into the category of rigorous social science. As Fuller notes, the value of *Structure* lies *'more in the spirit of metaphor than evidence'* (Fuller, 2000: 227).

Even as a metaphor, Kuhn's presentation exposes two problematic assumptions of the knowledge economy view of innovation. First, in agreement with the models of internal scientific credit

²⁰ References to Hacking's essay refer to the 4th edition publication of *Structure* (London: University of Chicago Press, 2012). All other references to *Structure* with individual page numbers refer to the 3rd edition publication (London: University of Chicago Press, 1996). Both editions are included in the bibliography of the thesis (9).

proposed by Bourdieu, Latour and Woolgar, and Knorr-Cetina, it challenges the idea that scientists are motivated to concentrate upon instrumental, technological innovations. Rather, *Structure* tells us that scientists are concerned mostly with supporting the current paradigm of normal science, and that this work is not geared towards the production of '*major novelties*' (Kuhn, [1962] 1996: 35)

Structure prompts the question, that is beyond the means of this thesis to answer, of whether normal science or scientific crises are most conducive to profitable knowledge. When Schumpeter referred to profitable innovation, he seemed to have in mind a collapse of the old order akin to a scientific revolution. He spoke of the '*creative destruction*' of old industrial processes and products; a destruction triggered by the creation of basic knowledge, novel manufacturing techniques and new products (Schumpeter, 1954: 1027). The second assumption exposed by *Structure* is the time-scale in which scientific advances are made. *Structure* argues that scientists are prompted towards novelty because the normal paradigm has been called to question; and in these crisis periods, *theoretical* novelty is sought. From figure 3.2 however, we can see that moments of paradigm change are relatively rare. For most of the time then, the '*money and talent*' of science is dedicated to confirming the normal paradigm (Hacking: xvii). In sum, *Structure* shatters the assumption of linear model of techno-scientific innovation purported by knowledge economy policy; and more pressingly, raises the question of whether scientists can be lured away from the structure of normal science, to develop a pattern of working that esteems instrumental innovation at the expense of advances in theoretical and experimental knowledge.

Policy-makers seem to have little regard for the complexity of the science studies view of innovation; furthermore, there is a possibility that the contemporary doctorate does not encourage PhD students to challenge scientific paradigms. Indeed, the 2002 Open University handbook '*How to get a PhD*' explicitly advises against creative destruction:

The PhD has always been about making a contribution to the normal paradigm. The theory of relativity was not Einstein's PhD; Das Kapital was not Marx's.

(Phillips and Pugh, 2002)

When this advice is considered alongside the literature depicting early-career researchers as intent upon building their scientific capital before they challenge orthodoxy - adopting a risk-averse and careerist approach to scientific research (Lawrence, 2002: 836) - the question arises of whether UK

policy-makers are aware that their investment in high-value STEM human capital may take a long time to translate into scientific innovation and profitable applications. It is uncertain whether the contemporary STEM PhD model sufficiently encourages the development of the '*inventive personalities*' - that Kuhn associated with divergent thinking and the push toward scientific revolution (Kuhn, 1979: 239). The value of these reflections is that the assertion of a quick or straightforward financial turn-around from human capital investment - as suggested by government rhetoric - can be seriously called into question.

The limitations of the government view are apparent in the Conservative party commissioned report *Ingenious Britain* (2010). The report, conducted by the inventor James Dyson, focused upon how to cultivate successful STEM entrepreneurs, much like Dyson himself. In this report, an exploration of how innovation might be conceptualised is overlooked, instead it is assumed that by combining human capital with university-industry collaborations or a high-tech company, profitable innovations will follow. Nothing is said about the state of scientific knowledge, or of any conflict between scientific identity, career ambitions, and the entrepreneurial mindset (Dyson, 2010:6). The fact that attracting scientific talent to industrial research may be a problem is ignored. This is significant, because the evidence suggests that most scientists prefer to work in academic research environments wherein they perceive more freedom; and moreover, that scientists are willing to take a lower salary in exchange for their preferred working conditions (Dasgupta and David, 1994 and Belenzon and Schankerman, 2008, cited in Vaitilingham, 2010: 9).

Further implicit in the report is a simplistic bundling of science and technology that would infuriate many historians of science. Policy-makers may be disappointed with historical evidence that points to a long wait for the fruition of commercially successful technological innovations. Cardwell argued that most technological improvements are '*evolutionary*' and so it can be difficult to record the moment of their inception, secure intellectual property rights and measure impact (Cardwell, in Rousseau and Porter, 1980: 473). Rosenberg described how economically successful innovations rarely occur in isolation; rather they depend on interaction with other individual inventions (Rosenberg, 1982: 56). It can therefore be extremely difficult to anticipate the applications and benefits that might flow from a single innovation (Ibid.: 57). The reception of society to the new invention is of course another critical variable in determining the measure of its success (Rosenberg: 55). Economic growth occurs when technologies interact; however this process is lengthy and protracted. Innovation cycles certainly do not fit with the clean projections and short

political terms of government, and it is precisely the reason why the exact economic benefits of Cold War America's 'science push' could not be entangled.

Knowledge economy policies assume a predictive power, underpinned by faith in a teleological, neoliberal model of growth. The trajectory is one of linear growth: greater input - human capital plus spending on R&D - is signaled to lead to greater output - innovation and economic growth. This account ignores the structure of scientific revolutions, and cycles of scientific credit, that may unsettle this trajectory. Furthermore, it ignores the methodological problems of measuring innovation, noted by Cardwell. There is a strong suggestion that patience and freedom are important in allowing science to innovate, but these are not values which politicians are popularly known to have sympathy for.

3.3e The scientist re-imagined

The sum of the science studies literature points to an altogether different image of the scientist to that which we have encountered in either the knowledge economy literature or the narrative of modernity.

On the one hand, it is suggested that the scientist is not the disinterested, pure figure painted by modernity. The scientist is instead conceived of as an assertive and interested agent. These interests are at once multiple, relating to: individual career prospects, as per the image cast by Latour, Woolgar, and Bourdieu; disciplinary affinities (Gieryn); cognitive habits, or the real-world conditions of one's research group, laboratory and available funding (Knorr-Cetina). Furthermore, what we are told about how the scientist handles non-scientific factors in scientific life stands in contradistinction to both the narrative of modernity and the knowledge economy. From the science studies literature, we are told that the scientist is an astutely political actor, able to influence science policy favourably by convincing other agents that what is good for science is also a general good (Latour and Callon). Indeed, we are told that the reason for science's long-held association with the paradigm of modernity owed less to the commitment of the scientific community to universal truth and the scientific method, and more to the pragmatic realisation that modernity assured the autonomy and financial security of science (Mulkay; Ben-David). Science is pitched as a political and a self-serving community; undermining the notion that knowledge economy policies arrived independently of the wishes of the scientific community, or that they might be successful without its approving participation.

The science studies view was not well received by the scientific community, which was perhaps all too aware that if society took seriously the above portrait; of factors additional to the scientific method having a role in knowledge production, or of the politically self-interested scientist, then the authority of science would be called into question and its credibility threatened. The image of the scientist as an independent voice speaking truth to power would be lost. This tension led to the so-called '*science wars*' of the 1990s. The point upon which most science studies scholars agree is that they are not trying to expose science as a non-rational pursuit, or the scientific method as redundant, but rather they are attempting to demystify, and in the process of doing so, it turns out that science is no more rational, objective or neutral than other social, political or economic institutions (Fuller, 1998a). Scientists nonetheless found this revelation '*threatening*'; the years of the science wars are characterised by the scientific community's public denouncement of their postmodern science studies critics (Fuller, 1998b). This antagonism of the scientific community towards science studies seems to have diluted in the present day. Arguably, there is now a greater awareness that making science more '*socially robust*' by improving the public's cultural understanding of science - particularly, by bestowing more realistic attitudes about science and its limitations - is actually a positive development for the long-term continued public support of science (Nowotny, 1999: 251; Fuller 1998b). If the lofty ambitions of modern science cannot be attained, then science may need a little help in readjusting its public image; this is precisely where science studies insights may help.

Science studies re-imagines the modern scientist and provides a more thorough consideration of the motivations and values of the contemporary scientist than we can find in the knowledge economy policy. This re-imagination is vital; modernity cannot continue to inform understandings of the scientist if the postmodern future that we face is the knowledge economy. At the same time, the convergence of state, society and economy implied in the knowledge economy raises a serious question of how the integrity and authority of science might be re-imagined in the knowledge economy. Clearly, the banner of neutrality is out of date, but this does not necessarily mean that science must lose its claim to expertise and the authority, not to mention public trust, associated with it. The challenge posed by the knowledge economy for the construction of scientific identity is a matter that we shall contemplate deeply throughout the thesis.

3.4 Concluding the critical literature review

Our survey of the science studies literature has left us with yet another distinct portrait of science and the scientist. Science is recast as a social organisation that is shaped by political and economic concerns, and it is suggested that individual scientists are used to playing political games in order to fulfil professional ambitions. The neutral automaton is replaced by a politically aware, emotionally invested social being; furthermore, an ANT perspective tells us that it is unlikely that knowledge economy policies could rise to prominence without the accession of the scientific community. Figure 3.3 below summaries the science studies view.

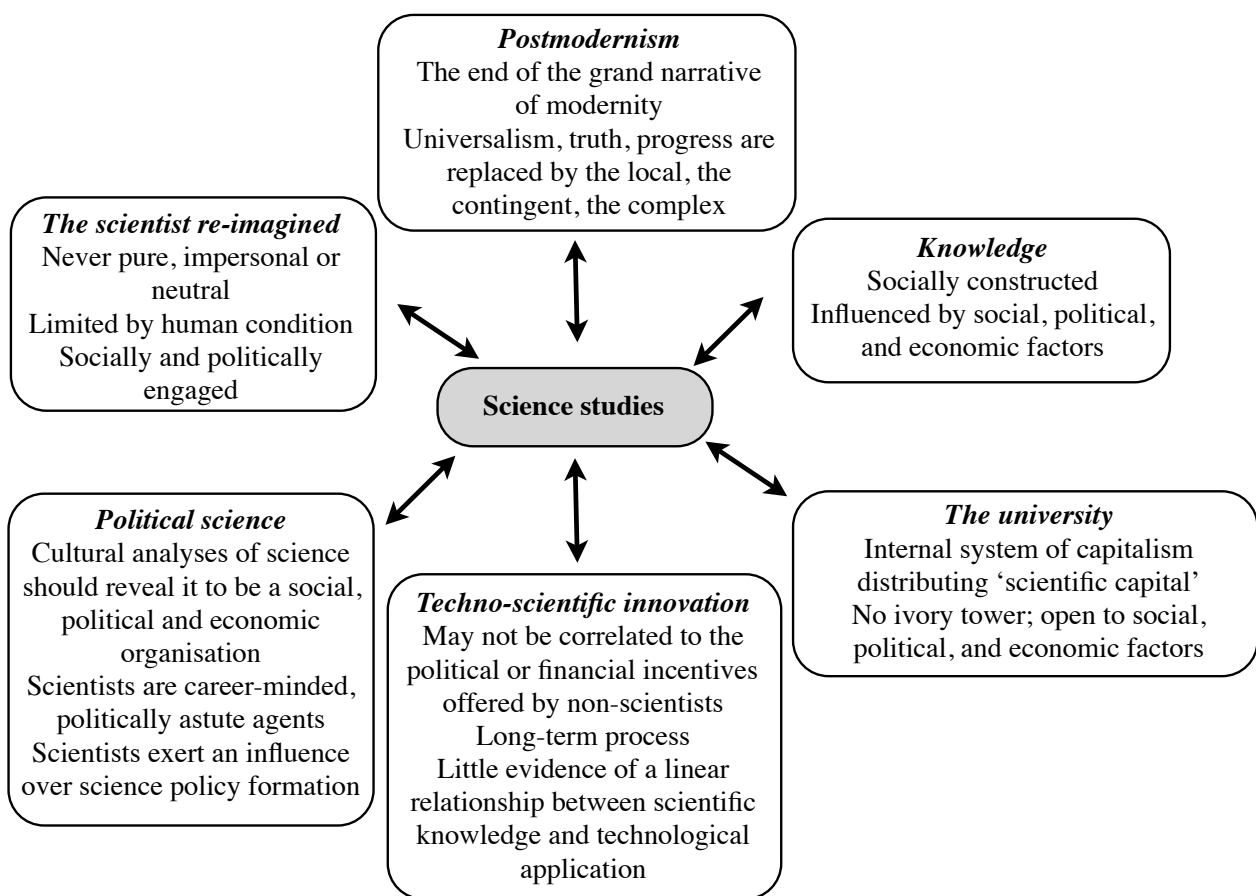


Figure 3.3 The view from science studies

3.4a Three visions of the relationship between higher education, science and the economy

We have considered three influential and competing narratives of science which are likely to inform how young scientists react to the knowledge economy, and indeed, whether they view the knowledge economy to be a positive or negative development for science. The necessity of such a thorough review of the normative literature on science is confirmed later in the thesis, when we see

how the paradigm of modernity, together with particular science studies theories are essential for making sense of young scientists' attitudes towards the knowledge economy. For the moment, we can remind ourselves of the main differences between these three competing visions of science in table 3.1 overleaf.

| <i>Modernity</i> | <i>Science studies</i> | <i>Knowledge Economy</i> |
|---|--|---|
| Modern worldview | Postmodern worldview | Postmodern worldview; shares the aesthetic characteristics of a modern narrative |
| Knowledge generates truth | Knowledge generates power | Knowledge generates economic growth |
| Knowledge fosters certainty and the management of risk | Knowledge is 'for cutting'; it reveals the limits of human understanding and the endless complexity of the human condition | Knowledge is for increasing economic growth and enhancing the earnings and well-being of individuals |
| Knowledge is universal, pure and objective (<i>realism</i>) | Knowledge is socially-constructed (<i>idealism/ social constructivism/ critical realism</i>) | Knowledge is global and economically valuable (<i>third-order capitalism</i>) |
| The production of scientific knowledge leads to certainty and progress | The relationship between scientific knowledge production and innovation is non-linear with little evidence of an association with political or financial interventions. Science progresses with paradigm revolutions | The production of scientific knowledge leads to innovations with profitable application |
| Academic freedom is essential for the production of truthful scientific knowledge | Academic freedom is a myth perpetuated by the scientific community; science is and never was pure | The delivery of social and economic impact, in the most efficient means possible, ought to be the guiding principle of scientific knowledge production |
| Universities are elite institutions that produce pure scientific knowledge, sheltered from political and economic concerns; and cultivate good citizens (<i>bildung</i>). STEM subjects are complemented with humanities and philosophy | The university perpetuated the myths of modern science; postmodernism has revealed it to be a sociological institution. The monopoly over knowledge is lost; its activities should be directed towards critical analysis | Universities provide mass higher education in order to develop a skilled workforce. STEM subjects are prioritised. Knowledge production is geared towards social and economic impact, through collaboration with external actors and industry |
| The scientist is neutral, objective, invisible; committed to the universal norms of the scientific community (<i>Mertonian norms</i>) | The scientist is human; science studies scholars can aid the scientist in the production of socially robust knowledge | The scientist is aligned with the values of the knowledge economy; profit maximisation is the aim. Meta-knowledge specialists may help the scientific community with the directing and management of research |

Table 3.1. Three visions of science

3.4b Introducing the research questions

From the critical literature review, three questions arise:

Research question 1: What evidence is there that the knowledge economy is a known phenomenon to young scientists?

Research question 2: If the knowledge economy is a known phenomenon to young scientists, do they express a moral position towards it?

Research question 3: How do the knowledge economy, and young scientists' moral positions towards it, impact upon their understanding and construction of scientific identity?

The first research question will enable us to ascertain to what extent the normative ideas and tangible policies of the knowledge economy have begun to impact upon young scientists as they study for their doctorate and plan their scientific careers. Secondly, I wish to question whether the normative ideas of the knowledge economy invoke a moral reaction from young scientists; in other words, do they express a moral position towards the knowledge economy? Do they deem knowledge economy science to be good science, or does it create problems and tension with other normative ideas about science that they hold? The third research question moves our consideration of the knowledge economy to the issue of scientific identity. Here, we go to the heart of the question of what it means to be a scientist today, and of the pressures that contemporary young scientists face as they construct a scientific identity to carry them through professional life. Does the knowledge economy, as the literature suggests, create a new role for the scientist and effect a corresponding shift in how scientific identity is understood? What do young scientists think it means to be a scientist today, and to what extent has the normative account of the knowledge economy impacted upon their understanding?

These research questions are important, not just for understanding how the epistemic culture within science may change in response to knowledge economy policy (Knorr-Cetina, 1992: 5); but also, in helping us to understand how cultural understandings of science and the role of the scientist may shift as a result of a dominant knowledge economy worldview (Cooper, 2002: 20).

4. Methodology: towards a reflexive, hermeneutic approach in the idealist tradition

4.1 Introduction

This chapter will detail and justify the chosen methodology of the research project. I begin by introducing the philosophical issues that informed the development of the methodology (4.2). This is followed by discussions of reflexivity (4.3); research design (4.4); data collection (4.5); and finally, the analysis of the data (4.6).

4.2 Nature of the inquiry

All research methodologies are anchored within particular philosophical traditions. This research project moves between the traditions of critical theory, idealism, social constructivism and critical realism. It should be evident that critical theory, concerned with the analysis of power relations, shaped the literature review; driving its concern to expose the power politics that underlie the dominance of the knowledge economy in UK policy pertaining to the areas of science, education and the economy. Critical theory is animated by the goal of emancipating the oppressed; fittingly, this research project aims to bring the hitherto neglected voices of young scientists to the policy debate.

Later in this chapter (4.6b), I suggest that the perspective of philosophical hermeneutics offers the most accurate account of how scholarly inquiry and knowledge creation occurs *de facto*. Philosophical hermeneutics posits that in any process of knowledge creation, the researcher must draw the horizons of others into the hermeneutic circle, so as to ensure that knowledge creation is inclusive of several viewpoints and, in consequence, is more robust. It should therefore not be seen as problematic to admit that instead of narrowly fixing to one paradigm, the research project took insights from several traditions and, as the data collection got underway, I opted for a mixed methodology. For the moment however, we are concerned with the philosophical issues underpinning the inquiry, and I will now explain why idealism, social constructivism and critical realism were selected as the most appropriate theoretical frameworks.

4.2a Ontological commitments

The first philosophical question which faces a social researcher regards the nature of the world, and this question is addressed with an *ontology* (Cohen et al., 2007: 7). Ontological accounts are

typically positioned upon a spectrum. At one end there is realism, which states that reality exists independently, and that pure and objective knowledge of the physical and social world can be attained through either an empiricist or a positivist methodology. At the opposite end of the spectrum is idealism, which contends that knowledge is derived through human experience and subjective construction. Knowledge of the physical and social world is mind-dependent; therefore it is deemed inappropriate to employ the methods of the physical and natural sciences to cultivate an understanding of human knowledge and experience (Ibid.: 10).

All social research originates from an implicit ontological value, and the ontological basis of this project is most closely aligned with idealism (Clough and Nutbrown, 2002: 4). Idealism is deemed most appropriate for this research because humans, and human experience, are at the centre of the inquiry (Blaikie, 2007: 16). Consequently, the project does not aspire to produce universal or generalisable statements of the sort that realism encourages. As we will see later in the chapter, this ontological starting point has implications for the treatment of validity, reliability and bias (4.4e). That a social research project should align with idealism is not atypical; indeed, realism, and its associated empiricist and positivist methodologies, have been considered inappropriate for answering social research questions since the late 1960s (McIntyre, 1993: 159). In accordance with idealism, and the majority of contemporary social researchers, this project treats thoughts and values as necessarily individual and subjective; and the processes of perception, interpretation, and communication, upon which thoughts and values are based, as inexorably shaped by subjective experience (Kierkegaard, in Blackham, 1994: 16).

4.2b Research paradigm

From an idealist ontology, we are led to particular sociological theories of knowledge which share the idealist viewpoint that knowledge is shaped by subjective experience (Gergen, 1994). Research paradigms bring together an ontological statement on reality with theories of knowledge, and advise on the methods that ought to be used in the subsequent inquiry. Two theories of knowledge informed this project: social constructivism and critical realism.

Social constructivism sees knowledge creation as dependent upon the constructions of individuals and social groups. It purports that constructs, through which individuals make meaning of the world, are shaped by subjective experience, social exchanges and power relations. Put another way, social constructivism suggests to us that thoughts and values are co-produced by the individual

mind and the social environment. In terms of this research project, social constructivism reminds us to look to both the wider scientific community and the microclimate of a young scientist's research group as we try to make sense of their awareness of, and moral position on, the knowledge economy. Since the policy narrative of the knowledge economy is itself a social construct - dependent upon the visions and values of policy-makers, industrialists and academic theorists - its inherent knowability is called into question. If we treat the knowledge economy as a social construct, then it follows that young scientists' understandings of it will be contingent upon individual differences: cognition, preferences, choices, values, and so on. The purpose of this research project is to reveal and understand young scientists' attitudes towards the knowledge economy; thus, social constructivism says that we must start with the individual and recognise idiosyncratic responses as subjective yet valid. It follows that the findings of the thesis are also socially constructed; social constructivism states that research findings are co-produced by researcher and researched. There is merit in this evaluation since, as we will see in the next section (4.3), my academic background in politics framed the early development of the project.

The major limitation of social constructivism is that it can imply that all knowledge is socially determined, and it has little to say on how aspects of the *non*-social influence thoughts and values. On this issue, the instruction of critical realism - sometimes referred to as social realism - was greatly beneficial to the planning of the research and the handling of the data.²¹ Critical realism asserts that even a theory of knowledge rooted in idealism can benefit from drawing on certain aspects of the realist outlook (Benton and Craib, 2001: 119). Critical realism is socially situated but not socially determined, and this is where my research findings will be positioned. As per critical realism, I suggest that some sense-data accurately conveys the physical and social world, and that this sense-data co-exists in the mind alongside subjective experience in order to influence the formulation of thoughts and values.

Critical realism is most commonly associated with the philosopher Roy Bhaskar. Bhaskar's central premise was that humans possess both objective and subjective knowledge, and that both types of knowledge shape human understanding. Bhaskar termed objective knowledge statements as *transitive*; and subjective or socially contingent forms of knowledge as *intransitive* (Bhaskar, in Archer, 1998: 16). The social researcher must realise that both knowledge types co-exist and

²¹ Critical realism is also known as social realism; Michael Young, of the Institute of Education London, prefers to use this term.

acknowledge that even if one's primary focus is on constructs, transitive forms of knowledge may have been influential (Benton and Craib, 2001: 120). Simply put, an individual's judgement is typically a blend of fact and value. Across the dualisms of transitive and intransitive knowledge, the objective and subjective, structure and agent; critical realism awards both sides causal efficacy. These distinct ways of knowing are seen as interdependent, interactive and constitutive of one another (Ibid.: 132).

In the research project, critical realism allowed me to take seriously the structural impact of knowledge economy policies and the institutions of science upon young scientists; and to admit - as per the literature from science studies - that transitive knowledge of the laboratory, its equipment or funding regimes will impact upon the individual scientist's perceptions and values (Knorr-Cetina, 1981: 81). At the same time, the subjective must be noted too; since it is particularly the case in political and economic matters that subjective perceptions can impact upon reality, in the sense that they may lead the agent to act out a self-fulfilling prophecy. Bruno Latour's view of scientific knowledge production was precisely one wherein transitive and intransitive knowledge meet. In *Science in Action*, Latour describes science as a place where '*context and content fuse together*':

Science and technology is at once light and multiple. Multiple because it means mixing hydrogen bonds with deadlines, the probing of one's authority with money, debugging and bureaucratic style...

(Latour, 1987: 6)

Critical realism consequently instructs the sociologist of science to be mindful of the multitude of influences bearing down upon young scientists, and it is consequently necessary for the researcher to dismantle distinct parts of the young scientists' experience - within and outside of science - to enable a meaningful and comprehensive understanding of attitudes towards the knowledge economy. It is clear in the analysis and discussion chapters that recognising and deconstructing young scientists' moral positions on the knowledge economy required a blend of realist, social and subjective theory.

4.3 Reflexivity

Reflexivity is the process of reflecting upon knowledge and values derived from prior experiences. It sheds light upon how an individual's understanding of the social world is incrementally

constructed, and the practice of regular reflection allows for an appraisal of the ongoing validity or relevance of an established viewpoint. It therefore acts as a defence against undue bias (Burrell and Morgan, 1979: 244). Reflexivity is a key concept in the idealist research paradigm, which, as we have seen, emphasises subjective experience in the making of constructs. On a more practical level, reflexivity is an essential consideration for any social researcher, since the shared human condition makes it tempting to assume that one's individually-held constructs are generally held views (Ellis and Bochner, in Denzin and Lincoln, 2000: 743).

In order for social knowledge to be valid, it is vital that social researchers do not excessively impart their knowledge and experience into the analysis and reporting of the data. The most important reflexive process that the social researcher carries out involves a consideration of aspects of similarity and difference between their self and the research population. In this project, I shared more with my research population than simply the human condition. I was a doctoral student also, studying at the same institution, and eligible to attend research skills training courses alongside potential participants. Since the purpose of the project was to uncover the constructs and moral positions of young scientists, the most important point of reflection was to ensure that my views on higher education and science, together with the unique experiences of my PhD, did not influence the research agenda and data analysis. My interest in higher education and science owed to a background in politics, and my understanding of the issues had undoubtedly transformed through the process of the critical literature review (Schwandt, in Denzin and Lincoln: 190). Reflection generated an awareness of these differences, and as a result, in the focus groups and depth-interviews with young scientists, I was careful not to share my assessment on the research issues.

Throughout my doctorate however, a theme of difference between myself and the research population endured more strongly. As a HASS student at the institution, I belonged to a very small minority. I did not feel part of a 'student body' and I derived my identity foremost from my status as an employee of the university. I discussed the project with colleagues and supervisors, not fellow PhD students. Disciplinary empathy played a significant role in this theme of difference. As a HASS student, I had only a handful of tangentially related PhD students with whom I could discuss the project in a scholarly manner. I had only a limited understanding of the particular knowledge, practices and academic cultures of my STEM counterparts, particularly in the first year of the research. Of course I learnt more about the inner-workings of scientific life once the data collection

began, but I can confidently reflect that the research questions were grounded within the critical literature review and that the data collection was not biased by the sharing of my own viewpoint.

I kept a reflective research journal throughout my doctorate in order to trace my subjective experiences, and record them in a space distinct to the thesis. Using a reflective journal to document the researcher's experience of the research process is a widely accepted practice in the construction of valid social knowledge (Atkinson and Coffey cited in Gubrium and Holstein, 2002: 812). The journal provided a space for critical personal reflection, and deterred the negligent transference of my subjective biases into the thesis. This is not to imply that the thesis is without imprint of my own subjective perspectives. It is also not to imply that the subjective experiences of the researcher are without value. Ellis and Bochner (in Denzin and Lincoln: 740) assert that the researcher's prior knowledge can '*illuminate the culture under study*'; and Ellman agrees that, if a researcher experiences an emotional response to data, this can provoke deep insight (Ellman, 1991, cited in Clarke and Hoggett, 2009: 149). Idealism may acknowledge the centrality of subjectivity in meaning-making, but the unthinking imparting of researcher bias into the collection, interpretation or dissemination of data is guarded against. The reflective journal, premised upon a dialogic consideration of similarity and difference, enabled me to avoid this defect.

4.4 Research Design

Having discussed the philosophical and reflexive issues of the research project, I will now describe the research design. Specifically, this section deals with the research plan, sampling, ethics, and relevant issues of validity, reliability and bias.

4.4a Research plan

The project followed a mixed method approach, employing quantitative and qualitative data collection. Mixed method approaches are widespread in contemporary social research, on the basis that together they provide a superior insight into a multifaceted research issue than either approach would alone (Burgess, 1982, cited in Brannen, 1992: 11).

The mixed method approach is further justified with reference to the different research questions, which individually are best answered with different types of data. Research question number one: *What evidence is there that the knowledge economy is a known phenomenon to young scientists?* required the collection of quantitative data, since it queried young scientists' observations of the

knowledge economy and knowledge economy policies, in the context of university life. The point of research question one was to gain tangible evidence of the impact of the knowledge economy upon university life and the STEM PhD, and to ascertain just how widespread its impact was. In other words, it was a question interested in quantifying real-world experiences. Research questions two and three however required qualitative data, since they explored the value-judgements underpinning young scientists' moral positions on the knowledge economy, and in turn, what this meant for their identity construction as a scientist. These questions therefore, were interested in normative and subjective constructions. Furthermore, the mixed-method approach followed a carefully planned chronology; moving from a survey to depth-interviews allows the researcher to move from breadth to depth, so to ensure the production of a refined interview schedule that draws out the most salient issues across the survey data.

Figure 4.1, overleaf, outlines the research plan, as it occurred over three years. It should be noted that since the analysis was informed by grounded theory (4.6a), the process was iterative rather than strictly linear. The critical literature review, for example, was revised throughout the three years in line with significant policy developments and unforeseen themes that emerged from the data.

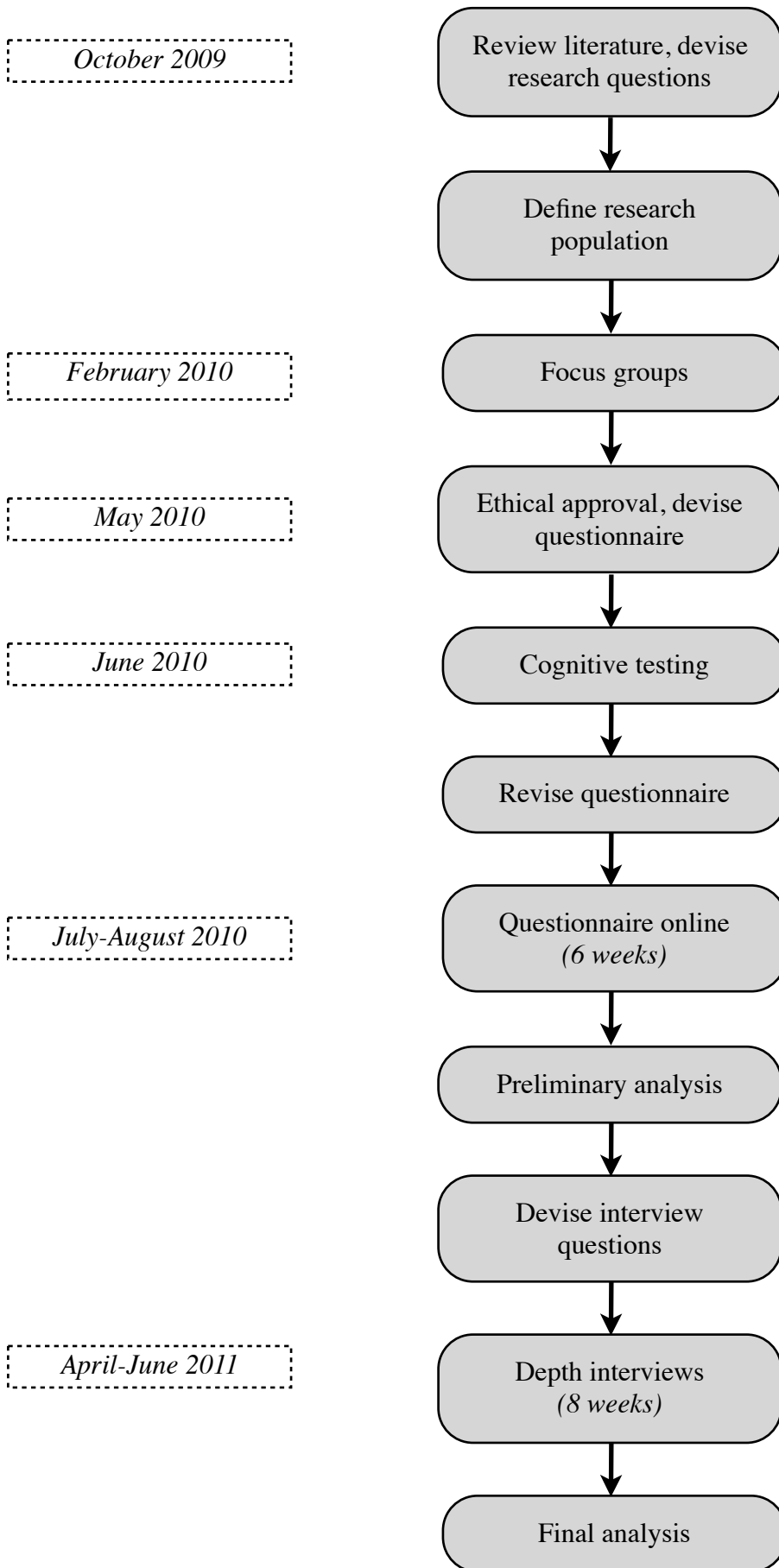


Figure 4.1 The research plan

4.4b *The institution*

It is necessary to mention the characteristics of the institution that the young scientists attended since the plethora of institutions that carry the name ‘university’ in the UK is extremely diverse. The institution is one of the few in the UK to specialise in Science, Technology, Engineering and Mathematics. Research-intensive and consistently rated as one of the world’s top higher education institutions, it also has a bigger postgraduate and postdoctoral population than the UK average. Located in the largest city in the UK, it expresses a commitment to the applications of academic research and partnership with industry.

*[The university] embodies and delivers world class scholarship, education and research in science, engineering, medicine and business, with particular regard to their application in industry, commerce and healthcare. We foster multidisciplinary working internally and collaborate widely externally.*²²

(2010)

The institution is also home to one of the UK’s first incubators for university-based entrepreneurship activities, which:

Combines the activities of technology transfer, company incubation and investment. Our goal is to bring valuable ideas to market either by building businesses or licensing to industry.

(2011)

The institution promotes the message of the importance of real world application to STEM doctoral students through the Graduate School, which runs transferable skills courses and holds an annual business month. Also located on the main campus is an internationally regarded business school, which names innovation and entrepreneurship as a central theme in its world class research programme; and, a research active humanities department, which brings together scholars from translation studies, the history of science and science communication.²³

²² Statements from the university featured in this study will be referenced with regard to a publication date only; this is to preserve the anonymity of the institution.

²³ The Humanities Department was undergoing restructuring as of August 2012.

Reflecting on the policy narrative of the knowledge economy, the institution would appear to be a vital stakeholder: an intellectual powerhouse committed to translating scientific knowledge into financial profit and evidence-based public policy. It is an institution that we would expect to be venerated by the policy narrative of the knowledge economy; as such, its unique features are not problematic for the research project but rather make for a fitting choice in this exploration of the impact of knowledge economy policy.

4.4c Sampling

All research participants were UK-domiciled STEM doctoral students at the science-focused research intensive UK university. According to numbers held by the registry, the sample frame equated to 1,321 students in the year of the online survey (2009-2010). Non-UK students were excluded because I made the decision to focus upon students who were likely to have had exposure to, and experience of, education in the New Labour years, when the policy narrative of the knowledge economy rose in prominence. In Punch's terms, these individuals were at the '*heart*' of the research inquiry (Punch, 2005: 101).

Participation in the project was voluntary. Volunteer samples are inevitably limited by the good will and time of participants (Bell, 1999: 126). The difference between those in the sample frame who do participate, and those who do not, is identified as '*non-response*' or '*sampling*' error. When research projects aim to make universally generalisable proclamations, calculating this error - usually by statistical weighting - is an important consideration. Owing to the idealist research paradigm of this project, generalisation, and thus calculating the sample error, were not pressing concerns. Achieving an in-depth understanding of young scientists' normative constructions of science, education and the economy was. All UK-domiciled STEM PhD students registered at the institution were invited to participate in the online survey. Access to the registry data enabled me to monitor how the research participants tallied with the sample frame, and I can confirm that the survey participants reflected the range of age, gender, discipline, funding source, education history and work experience found in the wider STEM PhD population. Survey participants were asked to indicate their willingness to participate in the depth-interview. Interviewees were then carefully selected, in the interest of capturing a spectrum of age, gender, discipline, past education, work experience, and attitude towards the knowledge economy expressed in the survey.

4.4d Ethics

Full ethical permission must be granted for any social research project (Bell, 1999: 37). No ethics procedure can resolve all problems, but approval does demonstrate the preparedness of the researcher to recognise their obligations to research participants. Furthermore, in problematic situations, approved ethical parameters can assist in devising the most acceptable way forward (Cohen et al., 2007: 381). This project received full approval from the Research Ethics Committee of the host institution in April 2010. I ensured that the ethics application followed the guidelines of the British Educational Research Association (BERA).

The biggest ‘cost’ of participation was time. This was particularly important since doctoral students notoriously lack time. The decision to hold preliminary focus groups (4.5a) meant that the survey questions were refined to focus on the most salient issues that arose in these discussions. The depth-interview schedule similarly focused upon the most pressing and interesting themes in the survey data. The research project was therefore designed to be as streamlined as possible; the incremental process of ‘narrowing-down’ the research focus meant that the cost to participants’ time was minimised, and also that the attention of the research was directed at issues grounded in the data. As an additional recognition for their volunteered time, survey participants could consent to entry in a prize draw for book vouchers, and those who participated in the interview received a small-value voucher for refreshments on campus.

The ethical application was submitted after the focus groups were conducted. I made this decision because by this point I had a clear idea of the questions that I wished to ask young scientists in the data collection, and I had decided not to use the focus group data in the thesis or any other written publication, thereby exempting it from ethical approval. Participants received a full briefing before the survey and the depth-interview. The survey was hosted online, and on the first page participants received a full description of the project, the aims of the survey, and the contact details of the researcher should they require further information. This page can be seen in appendix two. At the start of the interview, all participants received a participant information sheet and consent form. At both stages of data collection, participants were reminded of their right to withdraw their data at a later stage. All data reported in the thesis is anonymised; the survey data are presented statistically, and the depth-interview participants received pseudonyms. Individual characteristics that would otherwise risk exposing their identity are omitted from the written output. Access to the survey data

required a secure log-in known only by myself. An original spreadsheet linking individual participants to their pseudonym - necessary in the case of a request to withdraw data - was accessible to myself and the primary supervisor of the project.

Since the aims, procedure and intended use of the research were made clear at each stage, consent can be considered fully informed in all cases. There were no further queries after the data collection and I received no requests to withdraw data at any point. Participants were reassured that due to the nature of the inquiry, answers in the survey and interview could in no way be judged as 'right or wrong'; and I believe that stating this from the outset was important in encouraging openness in participation. Idealist social research is associated with the empowerment of the agent; an aim that I made participants aware of. In explaining how the voices of young scientists were missing from the policy debate on the knowledge economy, I hoped to inspire participants with the sense that the research may empower them, and that their contributions were essential. In addition to the thesis, I will produce a shorter summary document for circulation among students and staff at the host institution, so that young scientists receive something tangible from the project, that has the potential to influence the local policies that impact upon them. Finally, risk is a necessary consideration for all ethical applications; however, the perceived risks associated with participation in this project were considered to be very low.

4.4e Validity, reliability and bias

Validity measures how confident a researcher can be that their conclusions are 'true or false' (Cook and Campbell, 1979). Validity thus has an implicit affinity with a realist ontology. Validity in the idealist tradition generally demands that the following four points are taken into consideration.

Firstly, idealist research ought to ensure that the natural setting of the research population is the principle source of the data, so that data are socially situated in a meaningful sense and that cultural norms are built into the analysis and interpretation of the data. The data collection and analysis in this project met this requirement; being located at the host institution, and with the researcher's familiarity with the norms of the institution and the scientific community aiding the analysis. Secondly, the idealist notion of validity expects the social researcher to experience genuine exposure and interaction with the research participants in their social world. This can be accepted to have occurred since, as I have already stated, the data collection occurred in the university of the young scientists, and I conducted the focus groups and depth-interviews in person. Thirdly, validity

in the idealist tradition stipulates that data be analysed inductively, rather tested for ‘fit’ with predetermined categories. I followed a grounded theory informed analysis in order to meet this requirement (4.6). Finally, the social researcher is obliged to ensure that the research output honestly reflects the constructions of the participants (Lincoln and Guba, 1985; Bogdan and Biklen 1992, cited in Cohen et al.: 134). Since the analysis and discussion were grounded in the data, and coding categories emerged from the data rather than being pre-constructed by the researcher, I can be confident that this is the case with this research.

In addition to these general principles, there are numerous checks that researchers can perform on their method with regard to the many ‘sub-types’ of validity. In table 4.1 below, sub-types of validity, and how they were managed, are summarised. Where a sub-type of validity is regarded as not relevant to the research project, there is a justification.

| <i>Type of validity</i> | <i>Definition</i> | <i>Relevant</i> | <i>Justification</i> |
|-------------------------|--|-----------------|--|
| Internal | The phenomena described in the research output fit with the data collected | Yes | The use of cognitive testing. Structured survey and interview questions. The analysis is grounded in the data |
| External | The extent to which results can be generalised to the wider population, similar cases or contexts | No | For idealist researchers, generalisation is antithetical to the a priori assumption that human constructions and behaviour are context dependent and so diverse (Cohen et al., 2007: 137). |
| Content | The research sample is representative and the instrument of research measures what it is intended to (Cohen et al.: 137) | Yes | All UK STEM PhDs at the university had the opportunity to participate. The use of a mixed method approach to test for internal validity and ensure quantitative breadth and qualitative depth could be achieved. |
| Construct | That the terms used in the data collection are understood by the research population in the intended way, and the language of the research output reflects the meanings of participants' responses (Cohen et al.: 138) | Yes | The use of cognitive testing. Probing during the interview to ensure that young scientists understood the purpose of the question. |
| Ecological | The social world of the research population is conveyed truthfully | Yes | The use of grounded theory to analyse the data. |
| Cultural | The degree to which the research study is appropriate to the cultural setting (Cohen et al.: 139) | Yes | Theories and policies relating to the knowledge economy have the potential to impact directly on the research experiences and career prospects of young scientists and yet their views are a relatively unexplored part of the debate. |

| <i>Type of validity</i> | <i>Definition</i> | <i>Relevant</i> | <i>Justification</i> |
|--------------------------|--|-----------------|---|
| Catalytic | To ensure that, where applicable, the research findings give rise to action | Yes | Action here is understood to include the ‘potential for action’. In addition to the thesis, the written output of the project will include shorter documents that discuss the pedagogical and policy implications arising from the project, in a tone suitable for practitioner and policy audiences. |
| Consequential | The research conclusions must not overtake the intentions or the methodology of the research project | Yes | The chosen methods, data collection, analysis and discussion are committed to answer the three research questions in the greatest possible depth. |
| Criterion-related | Criterion-related validity asks whether the research is predictive, and if its findings could be obtained through other instruments of measurement | No | This is akin to generalisation, but applied to future generations. Such an ambition undermines the context-dependent emphasis placed on research findings by the interpretivist paradigm. |

Table 4.1 Sub-types of validity²⁴

Reliability checks for the consistency, or replication potential, of research results. It is therefore also rooted in a realist ontology, since it rests upon the belief that reality is objectively knowable and communicable, and follows regular universal patterns. The ontological assumptions of reliability thus stand in tension to a project moulded in the idealist tradition. Accordingly, reliability was not a pressing concern for the research process because I did not wish to prove the results could be replicated by another researcher. This is accepted practice in social research; indeed, LeCompte and Preissle argue that reliability is an unworkable objective for most idealist research (LeCompte and Preissle, 1993: 332).

²⁴ Types of validity as discussed in Cohen et al. (2007).

One way in which the concept of reliability can be useful in idealist research is with respect to checking for *internal consistency*. Internal consistency is comparable to internal validity, in that it monitors whether the administration of the research project has any effect on the collected data. Simply put, internal consistency ensures that the measurement of the concept is stable throughout the data collection. For example, it would audit whether the survey questions are understood in the same way by individual participants (Bryman, 2004: 52). While it may be expected that young scientists' express diverse reactions to the knowledge economy, it is important to have confidence that individuals understand the knowledge economy in similar terms. Checking for internal consistency is, in other words, a means to assure that young scientists' had in their minds the same phenomenon; the phenomenon of which I wrote in the literature review.

To check for internal consistency I took the measure of holding *cognitive testing* sessions with willing individuals from the research population before the survey went online. Cognitive testing allows a researcher to ascertain whether the questions are intelligible to prospective participants and that they measure what they are supposed to. Checking for this is important, given the multitude of ways in which a question can be interpreted and subsequently answered. Cognitive testing secures both the reliability and the validity of a piece of research, for if the instrument of measurement is proven to be accurate, then the responses will be valid (Office for National Statistics, 2010). I am confident that cognitive testing successfully resolved interpretation problems in this instance, and with the input of participants, the language of the survey was refined until a pattern of consensus formed with regards to how the questions were interpreted. By checking for internal consistency, we can be assured of the robustness of the social knowledge produced, and that the diversity of the complex data set displays genuine individual differences rather than differences of interpretation among participants (Brocke-Utne, 1996).

As with validity and reliability, the concept of bias is most readily associated with a realist ontology. This means that in idealist social research, we can think of bias in a more nuanced way. A narrow reporting of the data would be avoided at all costs; but it is impossible for the social researcher to make a claim of neutrality. Denzin (1997) tells us that all social knowledge is partial and biased to some extent. This need not be problematic; as mentioned in my consideration of reflexivity, Ellman (1991) believes that the relationship that exists between any researcher and their data is personal and infused with values; and that the intensity of this involvement can prompt great insight (cited in Clarke and Hoggett: 149). Research located within the social sciences ought to be

transparent regarding the role that social experiences, personal values and individual cognition play in its formation. I consider the presence and impact of these variables upon the analysis of the data shared in this thesis in section 4.6 of this chapter. Such a reflection is consistent with the hermeneutic tradition that this methodology identifies with.

One source of bias that I could not fully control for was the potential of my views on the knowledge economy influencing participants' responses. As I have already stated, I prevented this by refraining from discussing my thoughts on the knowledge economy with participants. In addition, as we shall see in the next section on data collection (4.5), the use of open-ended questions, together with the design of the research - refined at each stage in response to young scientists' priorities - meant that they, not I, set the direction of the research.

4.5 Data collection

In this section I detail the chosen methods of the project: focus groups, a survey and depth-interviews - with justificatory reference to the idealist research paradigm.

4.5a Focus groups

Prior to the survey, I facilitated three focus groups with young scientists. As stated, data from the focus groups were not included in the formal analysis; rather, the value of the focus groups was to provide an initial opportunity to assess the viability of the project - so to say, whether young scientists were aware of the knowledge economy and whether it was a topic of interest to them. The focus group questions can be found in appendix one.

Focus groups are an increasingly common practice in educational research (Cohen et al., 2007: 376). They are a low-cost, easy, and quick means to gather preliminary data (Burton et al., 2008: 175). The success of focus groups rests upon the social interaction between participants, who discuss issues raised by the facilitator (Gall et al., 1996: 308). The facilitator steers discussion, though discussion ought to be relatively unstructured and occur in an open environment, so that participants can turn their attention to issues that they find most interesting or meaningful.

Young scientists volunteered to take part in the focus groups, by responding to an email invitation sent out to all UK domiciled STEM PhD students at the university. In the first invitation, the topic of the focus group was stated; for focus groups two and three, the invitation was 'blank', since I

wondered whether the seemingly well-informed and politically passionate participants of focus group one represented a selection bias. This appeared not to be the case; participants of focus groups two and three turned out to be similarly engaged in the research issue. Participants were selected to cover a variety of disciplines, age, gender, and stage of doctoral study. The first focus group had ten participants; the second had eight; and the third had four.

At the start of the focus group, participants were informed that the discussion would be recorded but that it would not form part of the written output of the research. Participants were briefed that the primary purpose of the focus group was to scope and refine questions for the survey. All participants consented to this, in line with recommended protocol (Barbour and Kitzinger 1999: 17). In order to build rapport with the participants and put them at ease, I introduced myself and the project, and then invited participants to do the same, meaning that all participants had the opportunity to speak very early on. As recommended, the focus groups took place in a quiet room (Ibid.: 8).

At the time of the focus groups, exploring the attitudes of young scientists towards the knowledge economy made for an unprecedented inquiry. I had no prior evidence to indicate how informed and interested young scientists would be; nevertheless, their engagement with the research issue surpassed my expectations. Participants demonstrated a high awareness of specific knowledge economy policies such as New Labour's target of fifty per cent participation in higher education, and the increase in university-industry collaborations. The discussions were inclusive, and on questions of policy, young scientists' demonstrated firm and critical views and did not shy away from disagreement with their peers.

It was noted that abstruse policy terms, such as 'human capital', 'high skills society', or 'academic capitalism' were not commonly known to participants; and because of this I avoided using these terms in the survey. It was further clear that the question order affected the dynamics of the focus group. Participants were most open when the discussion started with a consideration of higher education policy, before moving to personal contemplations on the STEM doctoral experience. Participants were markedly less open, and the debate less animated, when the focus group began with questions focused on the personal experience.

In sum, the focus groups were highly valuable in ascertaining young scientists' interest in the project, and in the refinement of the survey questions - particularly with regard to language and order effects. Focus groups have been criticised for being unnatural settings, and for the limited degree of control that a researcher yields over the discussion and subsequent data. A further concern is that individual members of the group can dominate the discussion (Burton et al.: 175). In this example, I do not believe that the settings had a distorting effect upon the data, since the focus groups took place in a seminar room in the university where critical debate is expected to occur. While some participants inevitably had more to say on specific issues, all individuals contributed to the discussion and I allowed plenty of time for expression of the diversity of participant perspectives.

4.5b Survey

The purpose of the survey was to obtain systematic and definite information from a large number of young scientists, which would reveal the most salient issues and thus focus the depth-interviews.

I wished to trace young scientists' knowledge and experience of knowledge economy policies, but the knowledge economy is not a straightforward phenomenon to explore. As we saw in chapter two, even scholars of the knowledge economy cannot agree on one definition. Slaughter and Leslie's framework of academic capitalism has faced criticism for being '*too loose*' to test methodologically (Deem, 2001: 17). In contrast, the knowledge economy can be seen as 'too broad'. I have stated already that it is a social construct, a label under which several viewpoints and interests converge. Furthermore, I wished to investigate the knowledge economy alongside other normative accounts of science, education and the economy. The survey questions were designed to explore the array of ideas introduced in the literature review, and those exposed as important by the focus groups.

Table 4.2 below summarises the survey questions, detailing their origin and an explanation for their inclusion. A transparent overview of this kind supports the principles of internal, content and construct validity. The full survey can be found in appendix three.

| <i>Question subject</i> | <i>Source</i> | <i>Justification</i> |
|---|-----------------------------------|---|
| Awareness of knowledge economy, value-judgements on science, the economy, state and society | Literature Review | Central to answer research questions 1, 2, 3 |
| Functions of the historic (i.e. 19-20th C.) and contemporary university | Literature Review | Deepen understanding for research questions 2 and 3 |
| Functions of the STEM PhD degree | Literature Review | Deepen understanding for research questions 2 and 3 |
| Motivations for undertaking a STEM PhD | Literature Review and focus group | Deepen understanding for research questions 2 and 3 |
| Nature and purpose of the knowledge produced from STEM PhD | Literature Review and focus group | Central to answer research questions 2 and 3 |
| Academic freedom | Literature Review | Central to answer research question 1 and 2 |
| Stressors in STEM PhD life | Focus groups | Focus group participants were keen to discuss this. Views on psychological aspects of academic life inform understanding for research questions 2 and 3 |
| Career intentions post STEM-PhD | Literature Review and focus group | Deepen understanding for research questions 2 and 3 |
| Duties and responsibilities of the academic | Literature Review | Deepen understanding for research questions 2 and 3 |

Table 4.2 Summary of survey questions

Survey questions can take one of two forms: open or closed (Youngman, 1986). Both types of question featured in the survey. Demographic questions were placed at the start, before questions on awareness of the knowledge economy and its related policies. Emphasis was placed upon the fact that there were no ‘right or wrong’ answers, and that I was most interested in young scientists’ understandings and values. Final value judgements on the knowledge economy were asked at the end of the survey, in the hope of curtailing impulsive or ill-thought responses which might otherwise have been made at the start.

Most of the survey questions were closed, making them easy for participants to complete; they are quick, and, where there is an 'other' category, as in the case of this survey, closed questions need not compromise freedom of expression. Some questions had a Likert scale, where respondents can rate the strength of a given reaction. The validity of these scales had been trialled in the cognitive testing prior to the survey. The direction of the scales was consistent throughout the survey to reduce participant confusion. Closed questions have been described as 'stimuli' which provoke respondents to provide definite information (Seliger and Shohamy, 1989). I avoided the use of 'middle' categories, particularly in questions using a Likert scale, since middle ground options tempt participants to avoid thinking deeply on an issue and stating their position.

Closed questions are relatively quick to code and can be analysed statistically (Bailey, 1994: 118). The statistical frequencies generated by closed questions can be cross-tabulated against the individual differences of participants, to note patterns across the data and research population (Oppenheim, 1992: 115). I examined the survey data against variables such as age, gender, discipline, past education and work experience, and, as we shall see in chapter five, patterns were identified. Indeed, these patterns align with the data from other sociological studies of academic life; however, satisfactory insights into the causal direction of these relationships are lacking. There is little robust theorising that can be done on these observations, and to avoid a descent into superficiality, I will state now that statistical relationships do not assume central importance in the analysis and discussion chapters. After all, this is not the primary focus of idealist research.

Open questions featured too, allowing participants to provide more detailed answers, as is necessary when a complex issue is surveyed. Open questions are needed if there is the expectation of a discrepancy between the data used to inform the questions - namely the critical literature review - and participants' responses (Bailey: 120). Such a discrepancy was anticipated in this case, since the worlds of policy-makers and business, and that of young scientists, are very different. The obvious drawback of open questions is that they generate a large amount of data, some of which will be redundant to the research inquiry (Cohen et al.: 322). The coding of open questions is also very time-consuming (Bryman, 2004: 146). Nonetheless, I considered open questions essential for a deeper insight into young scientists' responses.

The survey was hosted online for six weeks, using a package created by Bristol Online Surveys (BOS). In this time, 165 young scientists submitted their responses. The response rate was 12.5%;

admittedly a minority of the research population, but nonetheless a legitimate statistical sample to work with (Cohen et al.: 101). There are good grounds to suppose that computer-based surveys return more honest responses, since respondents can complete their answers privately and anonymously. Computer-based surveys can limit '*prestige bias*' that often plagues social inquiry, wherein participants aim to impress or otherwise make an impact upon the researcher, and answer dishonestly as they try to do so (Ibid.: 158). Anecdotally, colleagues at the university warned me that young scientists don't like to admit ignorance. With the online survey, a participant could admit little or no awareness of the knowledge economy, together with controversial views, without social ramifications. It is likely that the online survey was the easiest way to reach a large number of young scientists, all of whom had access to the internet either at university or home. Once completed, the survey data was stored online; freeing me from the need to transcribe the data and thus lowering the potential for error in processing the results.

4.5c Depth interviews

Depth interviews followed the survey providing the essential qualitative data in order to answer the research questions, and consistent with an idealist ontology. The interview schedule was crafted in response to a preliminary analysis of the survey data, and, of course, to provide a fuller answer to the three research questions. The complete interview schedule can be found in appendix four.

Structured interviews are thought to have higher validity and lower bias than unstructured or fluid approaches to interviewing, because all interviewees ought to experience the same process. A small degree of deviation from the script is permitted in structured interviews; follow-up questions can be asked to clear up misunderstandings and clarify meanings, and where necessary, interviewees can be probed and asked to elaborate their responses. This helps to enhance the researcher's accuracy in the tasks of analysing, interpreting and communicating the research findings; arguably more so than in the case of survey data.

Sixty-seven individuals - 41% of those who completed the survey - agreed to be interviewed, and from this sample, twenty were picked, to represent a mix of age, gender, disciplines, past education, work experience, and views on the knowledge economy. Having completed the participant information sheet and consent forms, young scientists were asked to reflect upon their survey answers from almost one year prior. At this stage, I wished to see whether participants' thoughts on the knowledge economy had undergone change. In the majority of cases, they proved consistent.

The interviews took place in a private room on campus, to secure participant confidentiality (Field and Morse, 1989). On average, the interviews lasted for one hour. Planning the duration of an interview is important, because inconvenience, fatigue and a dwindling attention span can skew data (Whyte, in Burgess, 1982: 111-2). The interview length worked well; I found the young scientists to be engaged, enthusiastic, and with plenty to say. Two interviews were notably shorter; however, these were not deemed to have 'failed' since the data were still used fully in the analysis.

Kvale highlights the extent to which an interviewer needs to be an excellent communicator (1996: 147). Where necessary, I asked a question in different ways, or provided analogies in order to consolidate a respondent's grasp of the question. The timing between questions must be carefully judged in depth interviews. Patience is essential for encouraging more timid interviewees to share their thoughts; nevertheless, if pauses drag out for too long there is a risk that an interviewee who does not have more to say will feel obliged to fill the gap anyhow, and provide an answer of little sincerity (Family Health International: 35). In order to prevent this scenario from the outset, I advised interviewees that non-responses were perfectly acceptable. The interviews were audio recorded, allowing for a full transcription of the data, which Silverman tells us makes for the most thorough and valid analysis (Silverman, 2001: 189). In addition to the audio recording, I made notes throughout the interview, partially as contingency, but also to record important non-verbal details such as impassioned speech, facial expressions and body language.

The interview situation is not a natural one and this has implications for validity, particularly from the deconstructive lens of critical theory. It has been suggested that power relations and rules govern the interview (Lee, 1993; Neal, 1995; Gewirtz and Ozga, in Halpin and Troyna (Eds), 1994; Hitchcock and Hughes, 1989). The question schedule, set by the researcher, could be considered as one such rule. This is in part mitigated in this project, since young scientists had already influenced the question schedule through participating in the focus groups and survey. Furthermore, the power of interviewees is significant, since it is they who provide the data (Walford, 2001: 90).

When planning interviews, researchers are often anxious that interviewees will purposefully distance themselves from the interviewer; they might not answer questions, or they may withhold specific information (Cicourel, 1964). Building rapport reduces the chance of this happening. I greeted my interviewees in a friendly manner, and explained the project in detail at the start of the

interview. I reiterated the point that there were no right or wrong answers. Such reassurances are thought to improve the chances of cooperation and openness from participants (Barker and Johnson, 1998: 230). I also reminded the interviewees that their data were vital to the research project. Oppenheim found that when participants feel integral to the research process, they provide more detailed answers (1992: 81-82). Once the young scientists understood more about my research; and, that I, like they, needed results to write a thesis, a shared empathy and trust appeared to take hold. On reflection, I believe that my shared status as a doctoral student demonstrated that the power balance between interviewer and interviewee was, in many ways, level thereby inspiring interviewees to engage with enthusiasm and honesty (Cohen et al.: 151).

4.6 Data analysis

Earlier in the chapter (4.2b), I noted how, by implying that all knowledge is socially determined, social constructivists can leave themselves vulnerable to questions about the legitimacy of their research findings. In other words, they may be asked why their account is any more valid or expert than another individual's appraisal of the data. Grounded theory offers a way out of this conundrum.

With grounded theory, analysis and discussion are rooted firmly in the data; the researcher must admit that their analysis, though valid, is not to be taken as exhaustive. Any particular analysis is also contingent upon the individual researcher, but this is not a problematic admission from the viewpoint of philosophical hermeneutics, as we will see in the final section of this chapter (4.6b). The aims of a grounded theory analysis are to provide an in-depth analysis, using rigorous critique; so that the research outcome can be identified as a scholarly piece of sociological work, and therefore differentiated from the other interest-driven statements in policy debate of the knowledge economy (Young, 2008: 105).

The combination of a social constructivist and critical realist outlook meant that the analysis stage of the project was concerned with examining the responses of young scientists, with reference to a context of cognitive, professional, temporal, social, political and economic factors. Quantitative survey data are limited in the extent that they can satisfy this depth of analysis; as I have indicated already, these data were perhaps of most use in terms of scoping issues and refining the process of data collection. Thus the survey data serve mainly as an introduction to the results; in the analysis chapters, I will explore themes mostly through the data from the depth-interviews. I believe that the personal stories of interviewees also make for a more accessible way to present the data.

4.6a Adopting a grounded theory approach

Since the concern of the project was to convey young scientists' constructions, I selected an inductive means of analysis. After extensive reading, I found that *grounded theory* provided the best guide for this type of analysis. First developed by Barney Glaser and Anselm Strauss in 1967, grounded theory has evolved to become a collection of techniques, which can be used fully or selectively to achieve an analysis grounded in the data (Strauss and Corbin, 1998: 9). Grounded theory is not the only option in qualitative data analysis. Content analysis is perhaps its rival approach, and it requires the systematic categorisation and classification of data (Cohen et al.: 475). Many of its steps are similar to grounded theory; however, the essential difference is that content analysis leaves the researcher only with codified data. Grounded theory goes further and leads the researcher to producing an analysis that has greater explanatory power, and thus, a more sophisticated answer to the research question.

In grounded theory, the categories and classification applied to data are *emergent*; crucially, they do not pre-exist the analysis. This does not mean a researcher is expected to approach the data blindly. The initial literature review is significant in partially setting the direction of the research, its questions, and the issues of interest in analysis. Nevertheless, the analysis that emerges in response to the research questions must be grounded within the data. I adopted three recommended grounded theory techniques in the analysis. These were: *coding*, *memo writing* and *constant comparison*. Coding starts with reading and re-reading the transcripts. Words, ideas, events, issues and comments that are significant or interesting are highlighted (Coles and McGrath, 2010: 133). The so-called 'mundane' must also be noted, particularly if these comments are recurrent (Ibid.: 133). With regards to the interview transcripts, I found that I could work intensively on two to three transcripts per day, opting to do alternative tasks in between, so that I would approach each transcript refreshed.

The type of coding described here is known as 'open coding' since the code names are generated from the data, and, in the initial stage, all aspects of the transcript deemed to be significant, interesting or recurrent were coded. It is a thorough and time-consuming process. After initial coding, codes are merged in groups on the basis of a similar theme. It is these themes that form the basis of the grounded theory. Refinement of these themes is achieved through the techniques of memo-writing and constant comparison. Memos provide a space for the researcher's interpretation

of the text to be recorded; this is where the theorising of the data begins to take shape. Memos also provide a valuable audit trail, that enables the researcher to look back upon the themes and to clarify their place in the formation of the grounded theory (Strauss and Corbin: 273). In constant comparison, the researcher constantly and randomly compares the themes and memos across all the transcripts, to gain a sense of how widespread particular themes are, or ascertain whether the distribution of themes is in some way correlated to the individual differences of the interviewees. Constant comparison continues until no more themes can be derived across the data. It is important at this stage to discern which themes are related and to begin conceptualising the relationships that may exist between themes. This process of refinement and contemplation ultimately leads the researcher to the central theme, which stands at the centre of an integrated and comprehensive grounded theory (Ibid.: 143). The central theme can be said to be grounded in the full data set; while the subsidiary themes that develop from it reveal the nuances within the data and may only relate to particular individuals.

The grounded theory analysis of course began with the survey data. In the next chapter, closed-question data are presented in terms of statistical frequencies, through tables and figures (5b). The open survey questions are presented statistically also, which required the development of open coding categories. To share one example, we can consider the open question: *'What do you think caused the shift to a knowledge economy?'* which prompted a diversity of answers from young scientists. Answers were read repeatedly, until a summary word was applied to each individual answer. Reading continued and alternative words were considered until a best-fit was reached. Summary words were then compared across all the answers, at which point it becomes clear if answers are similar and can be merged into a further coding category. At this point, a more appropriate word to encapsulate all the answers in one code may be chosen. If there are many codes, then it is because the differences between answers are deemed more significant than any similarities that they may share. In the case of this question, five final coding categories were reached, as can be seen in the opening section of 5b.

The treatment of the interview data was a far lengthier process, beginning with the task of transcription. Ten of the twenty interviewees were transcribed professionally; the others were transcribed by myself. A sample of the transcripts can be found in appendix five. The decision to do this was the result of a compromise between time-pressures and considerations of validity. Some social researchers argue that analysis begins with the process of transcription, because it requires full

immersion with the data. Taking this view on board, I was concerned that contracting out the full transcription would hinder the analytic process, and may thus prove to not be a time saving decision after all. Nonetheless, time was limited, and so I came to this position of pragmatism. Much editing of professional transcripts was needed to format them as I wished. Having done this, and re-read each transcript several times, I can say that by the time the coding began, I felt comparable familiarity with each interviewee's story. With the transcripts prepared, I began to engage with value-systems, perspectives and moral forms in the data (Silverman, 2001: 112).

4.6b Addressing the limitations of grounded theory

Following the steps of grounded theory was highly valuable in preparation for the theorising of the data that is shared in chapters five, six and seven. Nevertheless, I wish to dispel now any notion that simply following the textbook steps of grounded theory is sufficient to furnish an in-depth insight into the data, of the kind that follows in this thesis. Other processes are at work as a researcher tries to make sense of a large and complex data set, such as I faced. I wish to close this chapter by discussing philosophical hermeneutics, since I believe it accounts more holistically and honestly for the leap from *method to truth* in the development of an analysis.

Philosophical hermeneutics evolved in the early part of the 20th century, as a response to attempts to apply the methods of the natural and physical sciences to the humanities and social sciences. Hermeneutics is concerned primarily with meaning and understanding. Martin Heidegger was its principal instigator, and he believed that attempts to develop a formal methodology to encapsulate the process of meaning-making and understanding were misguided (Ramberg and Gjesdal, 2009: SEP). Formal methodologies tend to present meaning-making as a teleological advance towards understanding and the truth. For philosophical hermeneutics however, real understanding is grounded in reflection on, and perception of, the structures that shape our perceptions. Such structures, once unearthed, are presented within a hermeneutic circle, that reveals interpretative interdependence. If understanding is the whole represented by the circle, the method can only be one part. According to Heidegger, structures pre-exist understanding, meaning that understanding is always subjective; which places philosophical hermeneutics in alliance with the idealist paradigm and phenomenologically informed reflexivity that also compose this project's methodology.

Hans-George Gadamer later built upon Heidegger's beginnings. It is considered that his most important contribution to philosophical hermeneutics was *Truth and Method* (1960). Gadamer

believed that only hermeneutics held the key to understanding, particularly understanding of the social world (Gadamer, [1976] 2004: 11). While he acknowledged the importance of methodological concerns, he rejected the idea that methodological rules alone could endow understanding (Ibid.). Gadamer conceived of understanding as a '*dialogic, practical and situated activity*' (Ramberg and Gjesdal: SEP). Simply put, the situation in which a researcher works always determines their understanding and the application of a theory. To use Aristotle's distinction, Gadamer prioritised *phronesis* - practical wisdom, over *sophia* - intellectual wisdom. Formal accounts of methodology may purport that *sophia* is at the heart of understanding; on the contrary, Gadamer would see the situatedness and subjective experience of the researcher as paramount, and far from being a barrier to understanding, it would be counted as an enabling condition (Ibid.).

Philosophical hermeneutics speaks with truth to my own experiences of analysis and interpretation. In approaching the analysis, I followed the advised steps of grounded theory. As I read, coded, compared and made memos on the transcripts, I found however, that the intellectual content of the literature review and grounded theory, did not, on their own, bring about any sure conclusions. For example, I had, at the start of the grounded theory, assumed that the knowledge economy would in some way be incorporated within the central theme, since it was at the core of the critical framework of the literature review and the research questions. Looking for the central theme and sub-themes of the data was a somewhat troubling task. The links between the literature review, research questions and the data were neither forthcoming nor straightforward. Without an obvious central theme, it seemed as though the research questions might be answered only superficially, and that I was at risk of drawing upon an eclectic mix of explanations (Silverman, 2005: 121).

As the results chapters will detail, a central theme did come to light in time. The central theme is evidently grounded across the whole data set; problematically however, it concerned an issue that the literature review had not yet tackled in detail. This is the issue of *scientific identity*. Far from being a linear path to understanding, my experience of grounded theory showed it to be an iterative process. I had to visit new areas of scholarship in order to advance the central theme and thus my understanding and interpretation of the data. Had it not been for Gadamer's reassurance that understanding is a dialogic practice, I would have thought of myself as being unsound in my methodology; guilty of the superficiality and cherry-picking of theories that Silverman warned of. Philosophical hermeneutics offers a more candid and sound way forward. Needless to say however,

there is little discernible support for a dialogic approach to methodology to be found in the pages of most social science journals.

Nevertheless, if a body of literature casts an explanatory light over a data set, then the selection of those particular texts, providing they have been robustly tested against the data, should not be regarded as cursory or poor scholarship. Rather than chaining a researcher to a specific body of literature, Gadamer actively encouraged achieving some '*temporal distance*' away from the data, in order to nurture a deeper understanding (Ramberg and Gjesdal: SEP). I can reflect that this was a practice I found valuable; engaging in new literature on identity led me to new questions about the lives of young scientists, and I believe, generated insights into the data that I would not otherwise have accomplished. Chapter six will introduce game theory as a useful way of thinking about the data. This insight appeared while reading a book on this body of theory, for purposes unrelated to the project. As I reflected on the premises of game theory, I began to forge links with the data and found that it illuminated the stories of young scientists. Game theory offered a fitting and penetrative analysis of the data; and while I would not suggest that it offers an exhaustive or universal account, I can defend its inclusion on the basis that its appropriateness is grounded in the data, and that my perception of its appropriateness came after following the steps of grounded theory, by which time I had formed an intense familiarity with the data; able even to quote individual young scientists from memory.

Gadamer further emphasises the influence of practical and contextual factors in the process of analysis and interpretation. The particular direction I followed, in my reading on identity for example, was most certainly shaped by the *practical* and the *situatedness* of my circumstance. Early on in the process of the analysis, I had the fortune to meet two distinguished higher education scholars, both of whom are well read on the issue of identity. One Professor advised me to read Hannah Arendt for wisdom on identity; the other instructed me towards Margaret Archer and Mary Henkel. As the result chapters will indicate, it was the advice of the latter that I found to be most fitting in the case of the data. In comparison, I found the work of Arendt less accessible and less pertinent. Gadamer acknowledges the fact that the practical orientation of the researcher influences the outcome of understanding, something that can be traced in this case. I believe it is important to be honest about the role of happenstance in method, providing, as I attempted to ensure, that it is the issues *within* the data that remain the central focus for understanding and interpretation. Gadamer

believed it was a sign of strength, and not weakness, for a piece of research to make *'transparently clear the guiding pre-understandings'* (Gadamer, [1976] 2004: 39).

Thus I concur with the position of philosophical hermeneutics that intuition is an essential part of scholarly analysis, providing that a familiarity with the data has been accrued. As a final reflection, I note my agreement with Stefan Collini on this matter, since he suggested that the role of intuitive judgement in understanding and interpretation is not just a rite of passage for the newer researcher. Collini describes the *'default condition'* of the researcher as *'one of intellectual dissatisfaction'* (Collini, 2012: 66). Implied in this view is a judgement that no single method serves as an unshakeable route to understanding. From the methods available, all understanding remains partial; leading to the researcher's *'dissatisfaction'*. In the hermeneutic tradition, both newer and experienced researchers, ought to consider their work as only ever an *'interim report'* (Ibid.). The reason for this, we can conclude, arises from the limitation of formal method.

4.7 Conclusion

In summary, the project followed a mixed methodology, rooted in an idealist ontology. Social constructivism and critical realism guided the selection of the quantitative and qualitative methods. The analysis of the data was shaped by both grounded theory and philosophical hermeneutics. Throughout the planning the research, data collection and analysis, a reflexive research journal was kept in order to mitigate bias.

5. Analysis: Young scientists and the knowledge economy

5a. Introduction to the analysis

5a.1 Introduction

This chapter is divided into three sections, to adequately address the complex data that we are about to contemplate. After this brief introduction (5a), the analysis of young scientists' awareness of, and moral positions on, the knowledge economy is presented in two parts (5b and 5c), the themes of which will be introduced shortly. The analysis continues in chapter six, which focuses specifically on how young scientists construct their scientific identity. We will see how young scientists' moral positions on the knowledge economy, and their associated normative beliefs about science, can be linked to their research behaviour, professional networking and career planning. Our discussion of the theoretical and practical implications arising from the analysis is reserved for chapter seven.

Deciding how to approach the analysis and discussion chapters required a considerable degree of reflection, and the particular perspective that I offer is not exhaustive. I believe that the strength of my chosen approach is that it duly details the uniqueness of individual young scientists' stories, whilst drawing sufficient commonality across these individual experiences. The central theme induced from the grounded theory analysis is that of the importance of *scientific identity* construction to young scientists during their doctoral study.

In keeping with the hermeneutic tradition, this central theme is presented as the core around which a hermeneutic circle forms. The value of using a hermeneutic circle is that it enables us to understand *how* young scientists come to form a moral position on the knowledge economy, regardless of what that moral position may be. For all young scientists interviewed, their knowledge of, and moral position on, the knowledge economy correlated strongly to a construction of scientific identity. Thus, the hermeneutic circle shown in figure 5.1 overleaf provides an interpretative context for understanding the five heterogeneous moral positions on the knowledge economy found in the data.

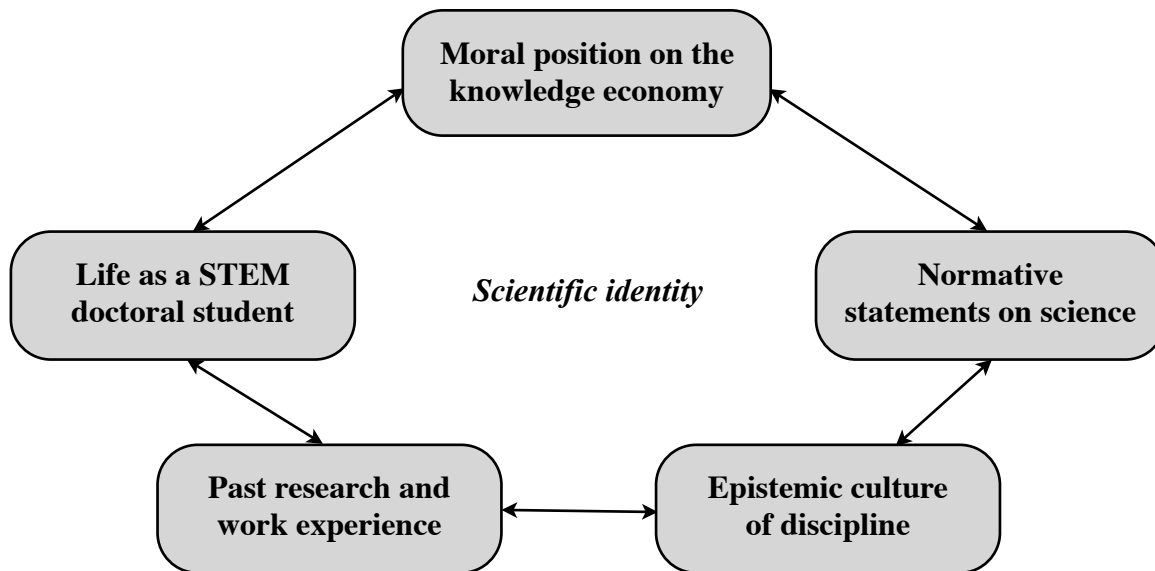


Figure 5.1 Hermeneutic circle of scientific identity construction

Through the analysis, it is revealed that young scientists seek *consistency* when cross-referencing the five aspects of the hermeneutic circle. Simply put, the scientific identity that they strive to attain is coherent, solid and stable.

The two remaining sections of this chapter (5b and 5c) expressly answer the first and second research questions; exploring whether the knowledge economy is a known phenomenon to young scientists, and whether they express a moral position towards it. The impact of the knowledge economy upon young scientists' constructions of scientific identity - the concern of research question three - is a theme that runs throughout chapters five and six, and receives especial consideration in chapter seven. Significant factors influencing young scientists' moral positions on the knowledge economy, and thus, their sense of scientific identity are identified as: discipline, past research experiences, work experience outside the university, and normative ideas about science. An association between discipline, gender and moral position can also be discerned.

5b. Five moral positions on the knowledge economy (I)

5b.1 Introduction

The following sections of this tripartite chapter (5b and c) will be primarily concerned with answering the second research question: *If the knowledge economy is a known phenomenon to young scientists, do they express a moral position towards it?* However, before this question can be addressed, we must turn our attention to data relating to the first research question: *What evidence is there that the knowledge economy is a known phenomenon to young scientists?* Whereas the second research question is answered mostly with reference to the interview data, evidence for the answer to the first research question is found in the survey data.

5b.2 A note on the survey data

Most simply, the answer to research question number one is that there is clear evidence that *the majority* of young scientists observe the anticipated phenomena of the knowledge economy in their day-to-day life as a doctoral student. Nevertheless, this conclusion was not immediately obvious from an initial glance at the first survey question. After learning that less than 40% (39.9%) of the 165 young scientists surveyed claimed to have heard of the knowledge economy, I feared that despite vast academic and policy literature, the knowledge economy was not recognised as a relevant phenomenon for STEM doctoral students. Further analysis of the data proved that this was not the case, but that young scientists did not recognise the *policy language* associated with the knowledge economy. Indeed, many young scientists were unsure how to define it. Despite this disconnect in the language of young scientists, and that of policy-makers and industrialists, the majority of respondents reported an awareness, and direct experience of, the knowledge economy. So while less than 40% recognised the specific term, 89% offered a valid definition of it, and these definitions were grounded in the daily experiences of PhD life.²⁵ Ultimately, young scientists' constructions of the knowledge economy matched those detailed in the literature review; we can be confident that respondents were talking about the same phenomenon, but in a different language.

Asking young scientists whether they observed specific anticipated phenomena of the knowledge economy provided more straightforward results, as table 5.1 demonstrates.

²⁵ The term 'valid' is used to describe a definition that matched a description or definition of the knowledge economy as given by one of sources consulted in the literature review. That is to say that if a respondent's understanding of the knowledge economy matched a construction of the knowledge economy evident in the academic, policy or industry literature, it could be said to be valid.

| Characteristic of the knowledge economy | % Observed |
|---|-------------------|
| The growth of multidisciplinary research | 86% |
| The active recruitment of international students | 86% |
| Growing concern for global university rankings | 77% |
| Encouraging doctoral students to be entrepreneurial | 71% |
| Pressure to conduct applied rather than basic research | 67% |
| Different treatment of STEM and HASS subjects by government and industry | 63% |
| Encouraging doctoral students to patent/ commercialise their research | 54% |
| Academics spending an increasing amount of time on industrial research | 51% |
| Declining freedom in choice of research topics | 39% |
| PhD students undertaking their degree primarily for its future economic value | 32% |
| Supervisors dedicating more time to industrially sponsored PhD students | 16% |

Table 5.1 Characteristics of the knowledge economy observed by young scientists²⁶

From table 5.1, we can see that distinct knowledge economy attitudes and policies appear to be filtering into the university research environment of the young scientist. From this, it should not be surprising to learn that 77% of young scientists agreed that a knowledge economy now existed in the UK. The causal reasons offered for the UK's shift to a knowledge economy were, however, mixed. These are shown table 5.2 below.

²⁶ Percentages denoting that more than 50% of young scientists observed the phenomenon are shown in bold.

| Explanations for the UK's shift to a knowledge economy | % Agree |
|--|---------|
| Economic/ structural change | 57% |
| Globalisation | 32% |
| The university | 25% |
| Technological change | 20% |
| Political intent | 12% |

Table 5.2 Explanations for the UK's shift to a knowledge economy

These codes were applied after young scientists had answered the question. Thus we can see a clear similarity in the way that young scientists' theorise about the knowledge economy and the arguments put forward in the literature review. Economic and structural change is a central cause of Malchup and Bell's theses; Castells makes heavy use of the concepts of globalisation and technological change in his *network society* analysis; and changes to the university are noted in the work of Gibbons et al., Etzkowitz and many science studies scholars.

Aside from pointing out this affinity between the suggestions of young scientists and those of literature, two further comments are worth making about this set of data. The first is that the young scientists regard political intent as a relatively marginal factor in bringing the UK knowledge economy to fruition. In my literature review, I argued that by defining a policy or activity as 'economic', it does not necessarily follow that it is apolitical. I attempted to demonstrate this by highlighting the neoliberal ideology behind much knowledge economy thinking. Nonetheless, for young scientists, it appears that talking about the 'economic' or 'structural' causes of a knowledge economy does imply the exclusion of the political; and moreover, political reasons are low down on the list of important factors. This theme continues in the interview data, when it becomes clear that young scientists hold little regard for UK politicians. Politicians may talk about the knowledge economy, but young scientists judge them to know little about the how and why of science; and therefore, politicians are deemed to be relatively disempowered when it comes to directing the development of the knowledge economy. The actions of those involved directly in scientific knowledge production - individual scientists; the university; industry, for example - are awarded a far more powerful role in the minds of young scientists.

Young scientists' attitudes towards politics play a significant part in this research inquiry, and I did wonder whether, in light of their downplaying of the political nature of the knowledge economy, young scientists would be reluctant to engage in a moral debate about it. As it transpired, young scientists were willing to engage in a moral debate about the knowledge economy; however, it is notable that this moral discussion revolved around the axis of disinterested academia vs. self-interested industry, and that downplaying the influence of political ideology formed a recurrent theme. Possibly, this is related to the expressed low respect for UK politicians, but it is nonetheless notable that young scientists do not classify scientists or industrialists as political agents, or recognise that the knowledge economy is in part a political project. This is perhaps one of our first clues as to the pervasive endurance of modernity in shaping young scientists' thinking: the separation of nature and society, science and the political, is very much still alive. Reflecting on this, I found myself speculating whether the labeling of the 'knowledge economy' – devoid of a reference to the political, and directing attention to the stark dichotomy of 'knowledge' and 'economy' - turns thoughts away from its political nature. Perhaps the question of why we do not commonly refer to the 'political knowledge economy' is an important one for interested researchers to consider.

The second point I wish to raise from the causation data relates to the clear inadequacy of the coding categories. I suspect that in many cases, a reference to '*globalisation*' meant more precisely '*economic globalisation*' and should probably have been included in the 'economic/ structural change' category. A further ambiguity stems from the 'university' category. Here it was unclear whether young scientists thought the university had a proactive role in bringing about the realisation of the knowledge economy, or was more of a necessary facilitator. Furthermore, if the university was merely a 'necessary facilitator', how has this role come about? Were universities forced into the role through cuts in public funding, pressure from industry or the collapse of the ideological project of modernity? I do not wish to overly problematise these acknowledged limitations of coding, but offer these thoughts rather to illustrate the importance of the follow-up interviews, particularly as we strive to answer research question two during the rest of this chapter (from 5b.2 onwards).

In addition to the evidence that the knowledge economy had begun to impact upon university life, the survey data revealed that young scientists viewed this impact to represent a historic shift in the institutional nature of the university. Young scientists were asked to complete a Likert scale

question, rating the importance of various functions of the university at two points in time: the 19th century (historic) and the present day (contemporary). It is important to note that in both time periods, the three most important functions stayed the same; with the *generation of new knowledge*, *teaching* and *research* topping the scale. However, the ten next '*extremely important*' functions indicate a great change in the university between these two dates. This change is illustrated in figure 5.2 overleaf.

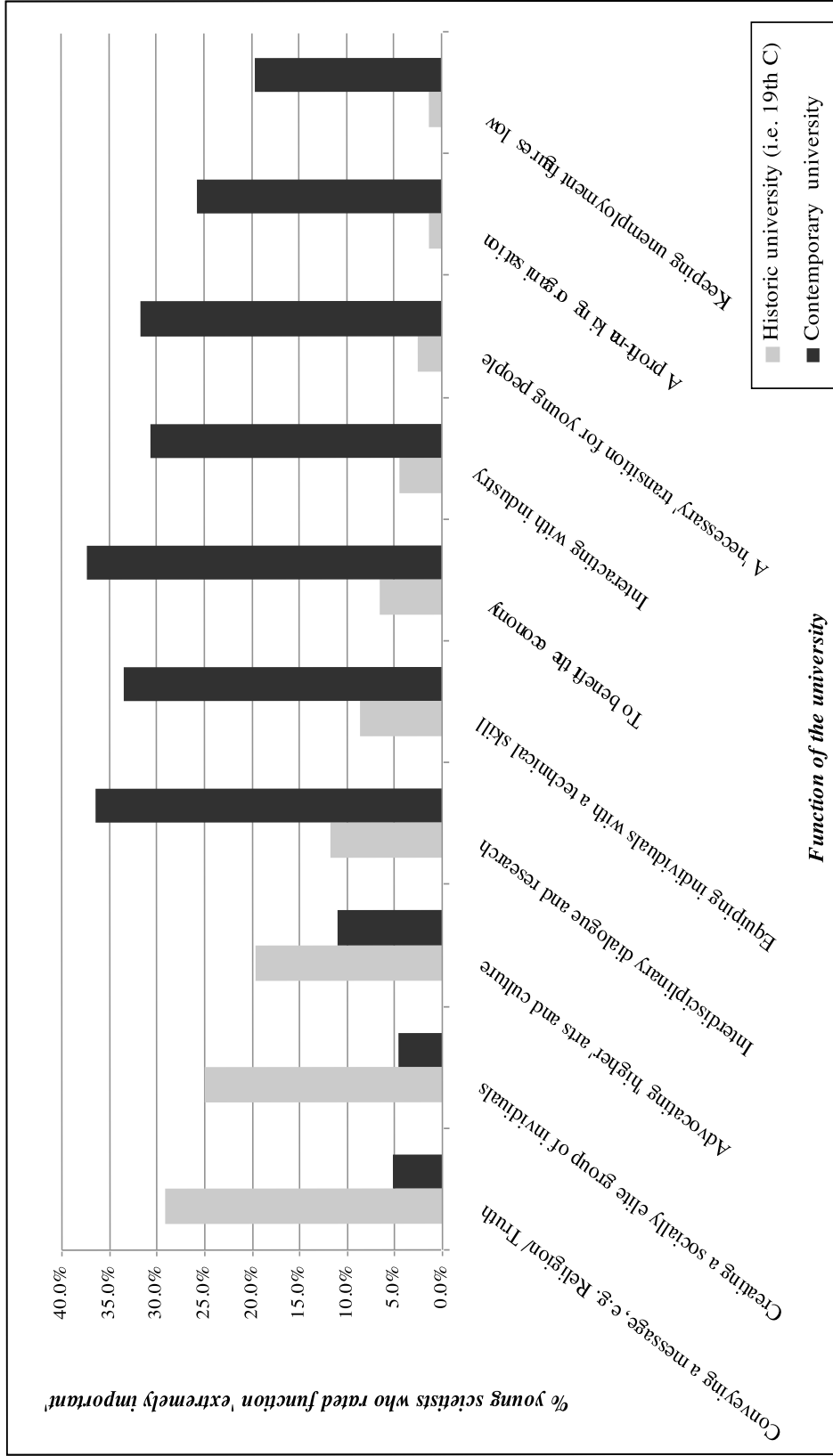


Figure 5.2 Young scientists' understandings of the functions of the historic and contemporary university

N.B. In both time periods, the three most important functions stayed the same; with the *generation of new knowledge, teaching and research* topping the scale.

Two observations arise from the data shown in figure 5.2. Firstly, it is evident that, over time, young scientists perceive the functions associated with the modern university to diminish in importance. During the same period, the functions associated with the university in the knowledge economy - such as economically valuable mode 2 knowledge production, industry collaborations and the delivery of technically-skilled human capital - rise in importance. Thus, the clear impression from young scientists is that the institutional nature of the university is evolving to fit the knowledge economy. Secondly, and related to this first observation, it is plausible to suggest that, if young scientists perceive a change in the functions of the university over time, then they are likely to hold some ideas about the basis for this change. Young scientists may not be familiar with the policy language of the knowledge economy, but nonetheless, their perceptions suggest that a phenomenon similar to the policy vision of the knowledge economy is responsible for causing this shift in the university's functions. Furthermore, young scientists are clear that the newly prioritised roles of the university represent nothing less than a break with history.

5b.3 Introducing the five moral positions

Having established that the knowledge economy is a phenomenon known to young scientists, I will now turn to the second research question: *If the knowledge economy is a known phenomenon to young scientists, do they express a moral position towards it?* In order to answer this question with depth, we will refer primarily to the interview data.

According to Ronald Dworkin, a moral position cannot: be based upon prejudice; be based upon an emotional reaction; be based upon implausible evidence; or, be argued for by citing the views of others only (Dworkin, 1977). To accept a position as moral, one must be confident that it is the product of reason and a set of feasible evidence. This is not to say, however, that *belief* and thus the non-rational play no part in the formulation of a moral position. On the contrary, a moral position arises when obvious 'right or wrong' answers are lacking.

Across the interview data, five moral positions on the knowledge economy can be discerned. That is to say, young scientists articulate five interpretations of the knowledge economy that were partially based upon rational evidence and partially based upon values. These moral positions are tenable statements about what is good for young scientists, the university and UK science in general. Furthermore, the moral positions adhere to the *incommensurability* principle in the philosophy of science. This means that because the moral positions are built upon normative assumptions

concerning education, the economy, science, knowledge, and the scientist, there can be no means through which to test which moral position is the most accurate or valid (MacIntyre, [1981] 2011: 8). In other words, we must accept the co-existence of these disparate moral positions, and instead focus our attention upon understanding how these moral positions come to be constructed, rather than making comparative judgements across the five standpoints. While the interviewees tended to express their views about the knowledge economy in a rational style of language, it remains the case that the moral positions are underpinned by normative - and thus non-rational - judgements about science. It is also important to remember that the moral positions are tied up with young scientists' constructions of their scientific identity, and while the majority attempt to construct a fixed and lasting identity, some of the students changed their minds about identity through the course of the PhD. These students will be introduced to us later in the chapter, and they are labeled respectively as 'weak' and 'strong' pragmatists (5c.2 and 5c.3). Bioengineer Rich is a weak pragmatist, and the following quote from him indicates the prerogative of some young scientists to change their view of the knowledge economy, desirable careers and identity over time.

[One's evaluation of the knowledge economy] *all depends on what you want to get out of your PhD.*

(Rich: 17)²⁷

Of course, '*what you want to get out of your PhD*', is something that will change for many young scientists through the course of their PhD. Nevertheless, only two interviewees remarked that they now disagreed with their answers from the survey. Rather than accepting ambiguity and revision as a normal part of the process of being and becoming, these young scientists hinted that they were uncomfortable with this inconsistency, and that, having now embraced a new perspective, they were confident that they had not had a proper sense of things before. In other words, there is the implication that past answers were different because they were in some way wrong. As Rich explained:

To sort of give you some background at that point I was actually going through a bit of a bad research patch, so some of the answers I've given may be a bit more cynical than perhaps I feel now.

²⁷Page numbers for interview quotes refer to the unedited transcript of each individual interview. Two sample transcripts, selected to represent two distinct moral positions, are copied in appendix five.

Sophia, the second young scientist to volunteer such a remark, confessed that she was: *‘in quite a bad mood with [the university] at the time’* of completing the survey, and that she *‘wouldn’t be quite so severe now’* (1). Notable then is that Rich and Sophia both blame emotions for their invalid outlooks of the past. These responses are reminiscent of Delamont and Atkinson’s 2001 study of young scientists, which found that they are likely to view inconsistency and revision in terms of a personal failing. Failure and uncertainty are not deemed to be part of normal scientific life; a message that young scientists probably accrue from their undergraduate experience of carrying out only ‘safe’ experiments, and from reading scientific textbooks and papers, in which ambivalence or failings are edited out (Delamont and Atkinson, 2001: 103). The young scientists in this study long for certainty and control, and they do this by constructing a resolute scientific identity for themselves.

In the remainder of this chapter, we will meet the twenty young scientists who participated in the interviews, and analyse the emergent five moral positions towards the knowledge economy. Table 5.3 overleaf shows some background characteristics of the interviewees. Following this is figure 5.3; a spectrum that maps out the five moral positions on the knowledge economy in relation to some of the main normative ideas about science introduced to us in the literature review. It may be useful to refer to both sources throughout the ensuing discussion.

| <i>Interviewee</i> | <i>Discipline</i> | <i>Age</i> | <i>Gender</i> | <i>Year of study</i> | <i>Source of funding</i> | <i>Previous HE</i> | <i>Previous work experience</i> | <i>Moral position on the knowledge economy</i> |
|--------------------|-------------------|------------|---------------|----------------------|--------------------------|--------------------|---------------------------------|--|
| <i>Alice</i> | Biology | 26 | F | 1 | RCUK | U. of Kent | Zoological society | Scientific purist |
| <i>Marigold</i> | Medicine | 24 | F | 1 | Charity | U. of Nottingham | University RA | Scientific purist |
| <i>Sophia</i> | Medicine | 27 | F | 2 | RCUK | U. of Durham | Hospital | Scientific purist |
| <i>Olivia</i> | Medicine | 24 | F | 2 | RCUK | U. of Oxford | Retail | Socially-oriented |
| <i>Rachel</i> | Conservation | 25 | F | 2 | RCUK | U. of Cambridge | Recruitment | Socially-oriented |
| <i>Charlie</i> | Biology | 25 | M | 2 | RCUK | U. of Bath | University RA | Weak pragmatist |
| <i>Jack</i> | Aeronautics | 23 | M | 1 | Military | U. of Warwick | MoD | Weak pragmatist |
| <i>Laurie</i> | Computing | 25 | M | 3 | RCUK | Imperial | Computing | Weak pragmatist |
| <i>Rich</i> | Bioengineering | 26 | M | 3 | RCUK | U. of Cambridge | Engineering | Weak pragmatist |
| <i>Rosie</i> | Biology | 38 | F | 2 | RCUK | Anglia Ruskin | Healthcare | Weak pragmatist |
| <i>Daniel</i> | Bioengineering | 23 | M | 1 | RCUK | Imperial | None stated | Strong pragmatist |
| <i>Dylan</i> | Engineering | 27 | M | 3 | RCUK | Imperial | Engineering | Strong pragmatist |
| <i>George</i> | Mathematics | 24 | M | 2 | RCUK | Imperial | None stated | Strong pragmatist |
| <i>Isabelle</i> | Engineering | 24 | F | 2 | RCUK | Imperial | Engineering | Strong pragmatist |
| <i>Simon</i> | Mathematics | 24 | M | 1 | RCUK | U. of Reading | Pharmaceuticals | Strong pragmatist |
| <i>Thomas</i> | Physics | 24 | M | 2 | Imperial | Imperial | None stated | Strong pragmatist |
| <i>Graham</i> | Computing | 28 | M | 2 | RCUK | U. of Sussex | Computing | Third-order capitalist |
| <i>Mohammed</i> | Engineering | 28 | M | 3 | Self-funded | Imperial | University RA | Third-order capitalist |
| <i>Toru</i> | Computing | 26 | M | 1 | Imperial | Imperial | Investment bank | Third-order capitalist |
| <i>Will</i> | Engineering | 30 | M | 1 | Employer | U. of Cambridge | Electrical components | Third-order capitalist |

Table 5.3 The interviewees

All interviewees were registered as full-time students. Age and year of study refer to that recorded at the time of the survey in 2010.

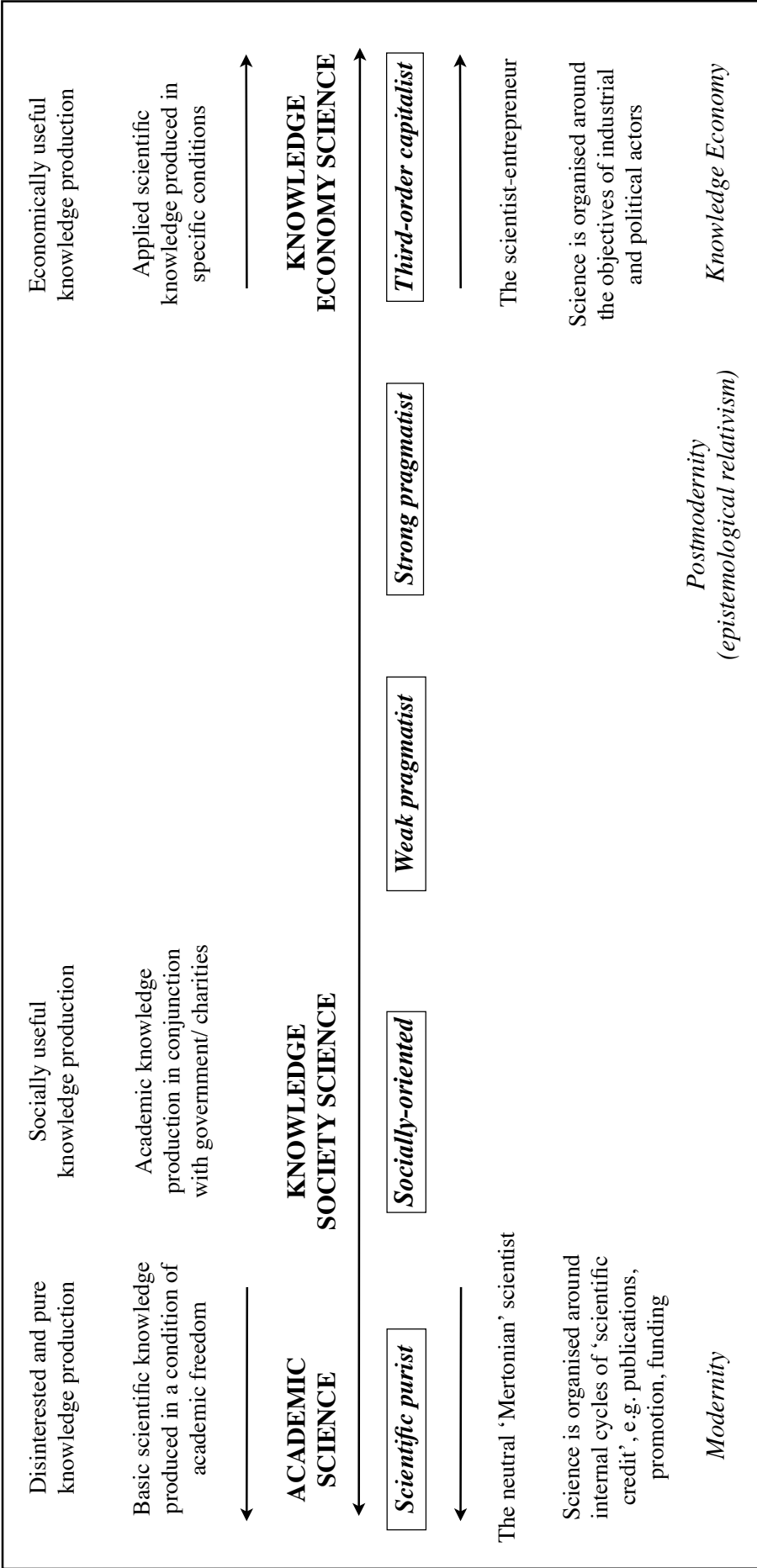


Figure 5.3 The spectrum of moral positions on the knowledge economy

The scientific purists and third-order capitalists sit at opposite ends of the moral spectrum. The position of the scientific purist conjures an image of the university that is similar to that of modernity. A disinterested approach to knowledge creation; pure research; blue-skies thinking; and, academic freedom are highly prized. At the opposite end of the spectrum is the position of the third-order capitalists. This position reflects the normative judgements of the knowledge economy narrative, valuing: university collaborations with industry and other interested agents; applied research; industrial R&D; and research that is directed towards clearly defined end-points. Occupying the territory in between are the socially-oriented, the weak pragmatists and the strong pragmatists. The socially-oriented young scientists aspire to a knowledge-rich society that uses its resources to enhance social justice. The weak and strong pragmatists, as might be inferred, are somewhat flexible in their decision of what counts as good science and a good context for science - to a lesser (weak) or greater (strong) extent. By the close of this chapter, the characteristics of each moral position, together with the differences between them, will be clear.

5b.4 Exploring the moral positions: the *anti*-knowledge economy outlook

For the rest of section 5b, we shall look at the two moral positions that can be classified as *anti*-knowledge economy. We look first at the scientific purists (5b.5), before turning to consider the socially-oriented young scientists (5b.6.)

5b.5 Scientific Purist

No one should approach the temple of science with the soul of a money changer.

(Thomas Browne)

I labeled the most ardent denouncers of the knowledge economy, ‘scientific purists’. By definition, a purist believes that something should remain as true as possible to its essence, and is free from distortive external influences. In the case of these students, science was that something to be protected, in this incidence, from the corruptive intervention of the knowledge economy. For the scientific purists, science and the knowledge economy were antithetical phenomena; the prospect of the two drawing closer thus implied a transformation in the nature of science, away from its true and pure form. Needless to say, these students can also be said to have a highly idealised image of science, and they protect this viewpoint with vigour. In addition, I will make the argument in chapter six that the adoption of such a fixed and absolute view of science appears to be indicative of

the naïvety of these scientists. It is fair to say that their expectations of science and scientific careers, are unlikely to be met in reality.

The scientific purists hold a view of science that is rooted in Enlightenment thinking, the realist ontology, and a positivist account of knowledge production. They uphold the sanctity of the scientific method, and purport that the role of the scientist is to accurately discover and communicate the universal truths of the physical and natural world. For the scientific purists, the university is viewed still as the modern ivory tower; sheltered from the influence of political, financial and public interests. The knowledge economy is rejected by the purists since it threatens the purity of this model; reprehensibly bringing private interests into the work of the disinterested scientist. The above opening quote of seventeenth-century English philosopher Thomas Browne makes for a fitting epithet. In a dismissive and succinct manner, second year medic Sophia explained, *'it's an attempt to fit academia into a capitalist economy'* (1). Sophia's reference to the knowledge economy as an *'attempt'* is telling; she didn't believe that the experiment would ever work. Furthermore, and following from the positivist tradition, the knowledge economy in itself was not regarded as worthy of proper attention by these scientists. As far as the scientific purists regarded the knowledge economy as the expression of human will - of politicians and industrialists - it was not scientifically verifiable; and thus, it was not a valid proposition (Kolakowski, 1972: 213). A normative and arbitrary construct; it had no place within the domain of true and pure science. According to the scientific purists, acceptance of the knowledge economy would not only challenge the integrity of the individual scientist, it would also hinder the revelation of truth and human progress that only science in the Enlightenment cast could furnish.

Three interviewees fell into the category of scientific purist: Sophia, Alice and Marigold. All were female, and found their disciplinary home in biological sciences. While a sample of this size cannot demonstrate a statistically significant relationship between gender, discipline and moral position on the knowledge economy, there are some comments that I can make, with the support of other studies. Firstly, it is important to note that discerning gender effect from discipline effect is notoriously difficult in any study of scientists. This is because of the contrasting disciplinary selections that male and female scientists make. In biology and chemistry, undergraduate courses tend to be split equally by gender (Donald, 2011). However, in the so-called 'hard-sciences' - which include physics, engineering and maths - the cohort of prospective scientists is overwhelmingly male (Ibid.). Thus, when we examine the position of the scientific purists, we cannot discern

whether it is gender, discipline, a combination of both factors, or an extraneous factor that has orientated these individuals towards this moral position. Nevertheless, the patterns in this data are evident; and should this study be repeated with another group of young scientists it would be expected that most scientific purists would be found among the female biologists; and as, we will see later in the chapter, that the majority of third-order capitalists would be clustered within the applied disciplines of computing and engineering. Correspondingly, third-order capitalists would also be more likely to be male.

There are some further thoughts that I can offer regarding the distribution of gender across the moral spectrum. It has been reported that within academic departments, women are more likely to be '*good citizens*'; so to say, they do more teaching and pastoral work than their male counterparts (Acker and Feuerverger, 1996; Poole et al., 1997). Whether this is a result of preference or institutional pressures is unclear; however it does suggest that women academics are committed to the Humboldtian ideal of unified teaching and research. One theory therefore, might be that the female scientific purists worry that these activities will be pushed further down the agenda of priorities if profit-making, patents and industrial research move up. It is also known that male researchers have higher publication records and tend to climb up the promotions ladder more quickly, and to a higher end-point (Acker and Feuerverger, 1996; Poole et al., 1997; Asmar, 1999; Barrett and Barrett, 2010). Perhaps this trend is underpinned by a careerist attitude inherent to male researchers, and the male propensity to welcome the knowledge economy can be explained in terms of an associated expansion of the opportunities to win funding, publish, and accrue more widespread esteem, authority and power. This certainly chimes with the image of the knowledge economy promoted by the policy literature; it is therefore plausible to suggest that female researchers base their aversion to the knowledge economy upon this predominant, commercial image. It would be unfortunate if this was the case however, because the knowledge economy is a cosmopolitan place, wherein the communication of science and public engagement also assume a greater importance than hitherto. Such types of knowledge economy activity may appeal to women, and do not threaten the Humboldtian ideal in the way that those other aspects of the knowledge economy might. Admittedly however, there is a counterpoint to be made that the types of knowledge economy work that may appeal to women could be considered less important in terms of academic promotion; further undermining the CVs of female researchers in an already unequal environment.

Sophia, Marigold and Alice specialised in medical research and biology respectively, and they gave clear evidence of how discipline had informed their scientific identity. In so far as what this meant for the moral position towards the knowledge economy, the deductions are almost self-evident; it would be far more difficult and contradictory to imagine bringing monetary and private interests into their work than it would be for the engineer or computer scientist. It is possible that stakeholders wishing to develop a knowledge economy in the UK may therefore wish to consider how its message can be re-branded in such a way as to appear non-threatening and compatible with those involved in the pure biological sciences.²⁸ Second year medical researcher Marigold recognised the fact that some profiteering may be beneficial in so far as it allowed academic research to safeguard its future development; however, she remained resolute in her rejection of bringing external private interests into science.

I just can't get past this economy word. I'm thinking it's like some kind of financial benefit. Maybe it would be good if the research was financially benefitting, but I tend to more think about the individual people who benefit rather than the greater research.

(Marigold: 7)

Second year Alice agreed that an increase in private interests' power to direct science would damage its development. She spoke of research becoming '*more esoteric*' in a knowledge economy, as research agendas were '*restricted*' in order to focus on politically favoured '*popular*' topics (Alice: 2). Using the example of climate change, she mused that it was now almost compulsory for funding applications in the biological sciences to make reference to it. Indeed, she was encouraged to do this exactly in her PhD funding application: '[I] *put a ten per cent climate change element in when you know [it's] actually a just a minor, minor bit*' (3). She was not proud of this practice, and worried that it was becoming more so the case; preventing scientists from '[getting] *on with the study*' and compromising the purity of their research (2).

Sophia elaborated the points raised by Marigold and Alice, on the importance of guarding against the influence of external actors on science, by suggesting that her discipline impelled her towards a particular political persuasion. By describing herself as a social-justice concerned '*Leftie*', she finds

²⁸ None of the scientific purists were involved in drug development, and so thoughts of healthcare 'products' remained distant to their PhD research.

further impetus to consider the knowledge economy, and its capitalist grounding, as unappealing. She explained:

To work in a research environment; you've got to be a bit of a Leftie. I think most of us are... especially in healthcare. And that's everyone, not just the PhD student. I think you'd find it difficult in healthcare to work in that setting and have quite a 'corporate view' of things, because it's a national health service! So we all have a kind of love affair with the NHS.

(Sophia: 12)

Perhaps owing to the anti-establishment heritage of Left-wing political movements, and also inspired by her realist view of knowledge, Sophia went on to confess that a further reason for her dismissal of the knowledge economy owed to the fact that she had little confidence in politicians, and their motivations. For Sophia, politicians' views of science were poorly informed, providing yet further justification for the exclusion of the political from science (10). Alice perceived the government's poor understanding of science to be a problem in the UK (12), and Marigold stated from the outset her caution of '*government directed*' research (1). The scientific purists can thus be said to hold a low regard for UK politicians, to the extent that they have come to distrust the promises of the knowledge economy. This perspective would need to be addressed by UK politicians who wish to persuade more young scientists like Sophia, Alice and Marigold that the knowledge economy could provide an attractive context in which to practice science.

Nonetheless, transforming the image of the knowledge economy into an attractive one for the scientific purists to consider migrating into might be yet further complicated owing to the importance of discipline to their scientific identity. This is apparent in Alice's confession: that a fundamental reason why the knowledge economy doesn't appeal to her is because she simply sees no place for herself within it (13). This is an important consideration, because the narrative of the knowledge economy is clearly not generating a message of inclusivity. Alice conceded, '*I certainly don't know if my PhD would fit in the idea of a knowledge economy*' (13). Despite her admission of detachment, Alice's tone carried the traces of a lingering anguish. For Sophia and Marigold the matter was more straightforward; for the reasons of disciplinary knowledge, and the culture they needed to produce it; the knowledge economy could be of no positive or meaningful relevance (Sophia: 12; Marigold: 1; 4).

Academia, on the other hand - posited by the scientific purists as in opposition to the knowledge economy - represented a context and future in which the scientific purists did feel as though they had a stake. The scientific purists were united in their primary ambition to forge an academic career; Alice had begun to look at postdoc opportunities (11), and Marigold admitted that this had remained her *'primary ambition...through the PhD'* (2). They upheld the view that the PhD was a time of apprenticeship for the academic career, and consequently thought that academic freedom and the production of publications composed its most important elements (Alice: 5, 6; Sophia 3, 6). The scientific purists cherished the supervisor-student relationship, and Marigold was particularly keen to defend the model against the claim made by some young scientists that it was a covert system of 'cheap labour'.

Some of my friends are more cynical. I've heard people saying that academic research is a pyramid scheme and that the PhD qualification is just cheap labour to get things done. It's not a view that I share.

(Marigold: 4)

Alice had two supervisors, one of whom was external to the university. This supervisor was attached to the charity that funded her, and she acknowledged the value of the external supervisor's different perspective, and the tension that this sometimes created between herself and her university supervisor. However, it is notable that Alice classified the external supervisor's input as non-academic, and quite at odds with the pure and focused approach of her university supervisor, who she recalled was *'always [asking] 'what's your original question again? And why have you been looking instead [at] this?'* (6). Thus while Alice appreciated the unrestrained way in which her external supervisor contributed to her project, there is a sense that it is the attentive university supervisor who is awarded the higher regard; indeed, we are given the impression that it is he who will ensure Alice answers her research question and can produce a thesis at the end of the three years. It is also necessary to remember that given the nature of Alice's funder - a non-profit zoological charity - no such 'knowledge economy' transaction is implied in this collaboration. Perhaps then, we can tentatively conclude that scientific purists may be amenable to research partnerships that are founded upon mutual disciplinary and academic interests, rather than monetary outputs.

The narrative of the modern university, outlined in chapter two of the literature review, appears to be the vision that the scientific purists relate to most strongly when envisaging their scientific life. It was noted in chapter two, that the narrative of the modern university stands in contradiction to the knowledge economy vision of the university and so the hostility of the scientific purists to the knowledge economy is to be expected. Sophia, Alice and Marigold had all completed their undergraduate degrees at other institutions. In fact, a glance at their alma mata - Durham, Oxford and Nottingham - indicates that the scientific purists have been privileged with a traditional and elite experience of UK higher education. In contrast, the university of their PhD is viewed differently. Though its academic excellence is undisputed, Sophia criticised the '*corporate*' feel of the institution (4), and went on to explain how this had influenced her disdain towards the knowledge economy.

I'm skeptical when I hear [the knowledge economy] in the context of [the university] because I've never been somewhere that is quite so corporate in its behaviours and operations; it has negative connotations for me. Maybe I would change my mind if I worked somewhere else but I just don't see that at the moment.

(Sophia: 12)

Adding substance to her accusation of the university's corporate behaviour, Sophia revealed that, in her opinion, her department took on too many international PhD students each year. She believed that the college took more international students than it could properly cope with '*because they pay more*' (2). However, Sophia speculated that the language and cultural difficulties often faced by these students, coupled with the '*the lack of support*' from the department, meant that UK doctoral students '*end up picking up the pieces*' (2). Sophia's anger over this situation was palpable in the interview. It cemented her belief that the introduction of profit-making incentives within a university would lead to a deterioration in the quality of provision, specifically undermining the Humboldtian ideal of interdependent teaching and research, since the adequate supervision of the international students seemed to have been overlooked by research-busy academics.

An overview of the scientific purists' account of good science suggests that Latour and Woolgar's seminal science study work *Laboratory Life* presents a rather accurate picture of the internal dynamics of science. In accord with Latour and Woolgar's account, the scientific purists tell us that the construction of scientific knowledge is focused on and shaped by internal factors; discipline, the

research question, and one's supervisor. Since the scientific purists all state the desire to forge an academic career it is not surprising that they were most focused upon what Latour and Woolgar would call '*cycles of credit*' which are internal to science (Latour and Woolgar, [1979] 1986: 187). This 'quest for credibility' means staying focused upon answering the research question, producing a good thesis, impressing one's supervisor, and achieving academic publications. These behaviours will be discussed in more detail in chapter six, but for now it suffices to say that the knowledge economy, and external actors, have little place in these cycles of credit. The situatedness of the scientific purists is clearly within the laboratory, within the university; and they see no reason to think beyond this - even as they look to their future career. To be fair, previous life experience would give them no reason to doubt this attitude; the scientific purists only held work experience related to their discipline, within the academy or public sector. As a final comment on the scientific purists, I am compelled to draw attention to the narrowness, or short-sightedness of their view. It is noteworthy that despite being funded by the UK research councils - a conduit for government research funds - and a charity, the scientific purists were sure that they could call their research 'pure' and devoid of political influence, as per the knowledge economy. This perspective seems decidedly naïve and inexperienced; a prospect that I explore more deeply in chapter six.

5b.6 Socially-oriented

Positioned next to the scientific purists on the knowledge economy spectrum were those interviewees whom I have named 'socially-oriented'. In contrast to their scientific purist peers, the socially-oriented young scientists welcome some aspects of the knowledge economy agenda for traversing the traditional dichotomy of science and society. The socially-oriented young scientists valued knowledge transfer, interactivity and transparency, and they believed in the forging of a new relationship between science and society, premised upon these values. For the socially-oriented, the university is an institution driven towards scientific excellence and, where possible, improving the public good. However, socially-oriented young scientists' acceptance of the knowledge economy narrative stopped short of tolerating the idea that private industry should acquire a prominent position in the relationship between science and society. Socially-oriented young scientists were as strongly *anti* the 'economy' aspect of the knowledge economy as the scientific purists. The difference between these two moral positions is that the former are supportive of opening up sites of scientific knowledge production to the public; so long as this relationship is founded upon a mutual concern for social - and not economic - issues.

The label 'socially-oriented' captures many of the central values that were expressed by two interviewees: Rachel and Olivia. In the discussion that follows, I will define the term, before explaining how it fits with Rachel and Olivia's discussions of science, themselves and the knowledge economy. The socially-oriented young scientists believed in the equitable distribution of social and economic goods, life-chances, and political power. The socially-oriented young scientists were concerned with ensuring that science as a specific community could foster an enhanced relationship with society, that would contribute to greater social justice. These socially-oriented did not talk of the scientific community challenging established political institutions or systems outright. What they had in mind was increasing knowledge transfer, improving the public understanding of, and engagement in, science, and prioritising scientific research that could lead to a social impact.

A commitment to social justice meant that the socially-oriented young scientists find neoliberal capitalism - upon which the orthodox knowledge economy narrative is predicated - troublesome; and so it follows that the knowledge economy view of science is also regarded as problematic. The moral position which they uphold echoes that which the philosopher of science, Derek de Solla Price, identified as '*little science*' in 1963 (De Solla Price, 1963). De Solla Price described little science as scientific activity that is geared towards addressing specific social interests. This is precisely the sort of socially orientated research that these young scientists wished to pursue; indeed they believed that good science would be built up from these principles.

Admittedly, Rachel and Olivia shared many traits of the scientific purists, and with regard to them, I uphold the argument made in reference to the scientific purists: that discipline is tied up with scientific identity and in turn influences one's moral position on the knowledge economy. Both were female, and located within the biological sciences: conservation and medical research respectively. They had also conducted their undergraduate degrees outside the university of their PhD, at Cambridge and Oxford. Both were research council funded, and Rachel in particular conveyed the same politically naïve appraisal of the scientific purists; that this source of funding was disinterested and tantamount to complete academic freedom (5). Olivia was less convinced of the disinterested nature of her PhD, since she explained that her project involved a healthcare company, which meant she felt obliged to stick with her specific research question, and that any patentable results would belong to the company, and not to her (9). While such involvement would have distressed the scientific purists, for the socially-oriented young scientists it is permitted. Since

Olivia's research dealt with cancer treatments, she had no anxiety that the incorporation of an external organisation compromised the fundamentally socially-orientated focus of her research. When Olivia reflected on her research, it was clear that she thought about it primarily in terms of its humanitarian and socially progressive character.

*Because I'm doing cancer research it's nice to think that I'm contributing to society.
You're thinking hey, you know, this kind of helps patients.*

(Olivia: 12)

Thus, the socially-oriented young scientists did not defend the purity of science with the same ferocity as the scientific purists. They thought of science as being inextricably bound up with social issues, and as being a driver of social - as distinct from economic - progress. Although Rachel was keen to state that she was 'very pro-valuing knowledge for knowledge's sake' (4), it was apparent, as she recounted her journey from undergraduate to postgraduate study, that the concept of 'science for society', was a significant factor in the development of her scientific identity.

My undergraduate was in zoology, and most of it was in behavioral ecology. My primary interest was in behavioral ecology, but.. in my opinion, [it's] not quite as useful as conservation, so I went into that. So there was a bit of pragmatism. I'm lucky that I work in conservation; I feel that it does have some value in terms of social or conservation value.

(Rachel: 4)

It is clear then that in the case of Rachel and Olivia, their disciplines - being located in socially valuable and non-commercial sectors - easily lend themselves to the moral position of being socially-oriented. At the same time, these disciplines mean that a scientific purist approach would be hard to maintain; Olivia's research is basic, but she alludes to thinking of patients' and their needs, and the connection of Rachel's PhD to the physical world is manifest. She spoke of the field work she conducted in America, and how she hoped to work in different universities after her PhD. Rachel was particularly keen to open her scientific research up to new influences, and to explore the different approaches, methodologies and mentalities of other researchers (9).

Both Rachel and Olivia aspired to become academic researchers, and they envisaged forging their brand of socially-oriented science from the site of the university. Thus, their image of the university academic marks another point of departure from the scientific purists. The socially-oriented young scientists thought that scientific research should be disseminated across disciplines and the public; it was not just for science students in a lecture hall. Rachel excitedly talked of the ‘*massive incentive*’ that a situation of freely flowing knowledge implied for her.

It's exciting that someone might be learning about what I discover, and not just in my area, but cross-disciplinary, or that some information I produce ends up being taught - that's incredibly motivating. I'm very pro- sharing data and information. Maybe that's a very naïve idea, and in ten years time, if I'm still working in academia, I will have changed my mind. But at the moment, I feel it would be a great thing, openness of knowledge. That's a great thing.

(Rachel: 12-13)

It seemed as though this was the only knowledge economy that Rachel was willing to recognise, since her starting definition of it was, ‘[the] *sharing of knowledge*’ between ‘*different people*’ (1). It is worth pointing out that Rachel’s emphasis upon the importance of knowledge networks is an aspect of knowledge economy theory, notably Manuel Castell’s *network society*, that most of the interviewees tended to overlook. Furthermore, Rachel’s lack of attention to the capitalist undercurrent of the knowledge economy should not be confused as political indifference to it. Her position as a socially-oriented young scientist is evidenced by other comments made in the interview. Her move into a PhD followed a year of work in the corporate sector; something she claimed to have ‘*really hated*’ (1). She juxtaposed for-profit organisations with academia; using her hatred of the former to explain her move into the latter, and she condemned private education because she believed that it led to socially inequitable effects upon educational choices and life chances (12). Thus Rachel’s keenness to open science up to the public is rooted in a desire to enhance social justice and mobility; she does not welcome the closer union of the private sector and science.

Rachel looked directly to her own PhD experience to assert the value of lay public input into the creation of scientific knowledge. She detailed how exchanges with her parents - both of whom were not university-educated - helped her to conceive of her research in alternative ways.

Sometimes the biggest points of progression I've had have been through conversations with other people.... In academia, we like to think we have this open and understanding outlook on the world, but you still think like a PhD student, or an academic. Speaking to my parents who are not scientists at all, they left school at sixteen, but they will ask me: 'Well, what does this mean?' and, 'Can you do this?', and that's definitely helped me to develop my thinking.

(Rachel: 9)

Rachel described herself as *'very family and friend orientated'*, and so it is plausible that her openness to the views of non-scientists on science is typical of her character. Olivia, on the other hand, suggested that her adoption of a socially-oriented outlook on science was relatively recent. Olivia's PhD experience had been fairly traumatic. She listed a poor relationship with, and a lack of respect for, her supervisor - *'my boss is an idiot'* (3); and her research not going to plan. She explained, *'a whole load of things just haven't worked... [they] aren't even negative; they're just nothing'* (4). The difficult reality of the experience was no doubt exacerbated by the fact that Olivia had not anticipated such setbacks. Her parents both held PhDs, and her husband was a university researcher. She hinted that she had embarked upon her PhD with the attitude that it was something akin to a rite of passage; acceding that she assumed she would one day become an academic:

I don't really know that much about other jobs... I always thought I would be an academic so I never really paid much attention to anything else.

(Olivia: 10)

Giving the impression of passivity, she joked *'if this is your name: you do a PhD'* (2). However, the trials and tribulations of her PhD meant that the Olivia of second year had developed a far more proactive perspective towards her doctoral research, and this attitude manifested as socially-oriented. So while the *'making-money thing'* of the knowledge economy made it *'off-putting'*, Olivia drew comfort from thinking about the importance of knowledge transfer beyond the scientific community and industry, and instead about the social impact of science (3). A communitarian and socially-concerned outlook was important within science too, Olivia argued. Unable to publish her PhD results, she remained adamant that she would make a valuable contribution to her field, explaining how after her PhD she hoped to work in a different lab where

she could share tacit knowledge and techniques; so to say informal scientific knowledge that would not normally be published (4). For Olivia, science was a community founded upon knowledge transfer. Due to this, when she thought about the knowledge economy expectation that today's young scientists would be the entrepreneurs of the future, she failed to see how it would happen. Observing her peers, she stated:

[The government] assumes that PhDs are then going to go and make patents or go into commercial things and suddenly generate loads of money, whereas people that are actually doing PhDs are doing it because they like doing science.

(Olivia: 4)

For this reason, she dismissed 'innovation' as a '*money-making word*' that had little meaning for the contemporary young scientist. The impact that the terminology of the knowledge economy narrative might have upon young scientists is something I address in chapter six but for now, Olivia's comments can be taken as evidence that language is not neutral; certainly, the language choices of knowledge economy stakeholders will be influential in shaping public support.

Like Rachel, Olivia believed universities should not behave as private corporations do, and she offered a simple maxim for universities' financial policy; '*you have to pay for things, but not profit*' (1). At present, she was worried that '*making money*' had become too much of an interest (1). This was not the point of science as far as Olivia could see, and most likely as a result of the adversity she had encountered, she was critical of the current norm in the UK of tying research funding allocations to individual credentials. On the contrary, said Olivia, '*you don't need a grant to do basic research*' (5); and furthermore, '*you don't need to do a PhD to contribute*' (3). A final contingent explanation for Olivia's turn to a socially-oriented view of science might be found in the UK's economic recession at the time of the interview. With a scarcity of postdoctoral positions in UK universities, Olivia suggested that it was perhaps time that academics did more to contribute to the society that funded them. She explained:

As an academic you think of yourself as a bit special: oh yes academia, I'm doing science. You think to yourself you're a bit above wage-slavery, economic concerns but that's not true at all. Calling it the knowledge economy makes you realise yes, you know, PhDs are nothing special actually; there are a lot of you, you've got to contribute too.

(Olivia: 12)

As far as this 'contribution' related to a social good, Olivia took no issue with it; after all, it was a criterion her research complemented perfectly. In addition to the very clear case of Olivia's scientific knowledge leading to a socially valuable product, Rachel was extremely motivated by the thought of sharing her knowledge through teaching and outreach activities, particularly in order to encourage more environmentally sustainable lifestyle choices (7, 11). This attitude is reminiscent of the emancipatory potential of scientific knowledge, identified in Nico Stehr's knowledge society (Stehr: 258-9). Rather than adopting the positivistic view that knowledge emancipates because it fosters certainty, Stehr argues that the individual in the knowledge society will be empowered by a greater knowledge of risk, power, and the ability to deconstruct knowledge claims (Stehr: 259). In Giddens' terms, the individual in the knowledge society uses knowledge to reflexively consider their actions and those of society (Giddens, 1991). This image chimes perfectly with Rachel's vision; she hopes that she can disseminate her conservation knowledge so that individuals reflect upon their behaviour and endeavour to become more environmentally friendly.

The socially-oriented young scientists are open to a knowledge society, but they cannot accept the encroachment of capitalism into science. Despite their agreement with elements of Nico Stehr's knowledge society, when compared against the policy orthodoxy of the knowledge economy, they can only be said to be anti-knowledge economy.

5c. Five moral positions on the knowledge economy (II)

5c.1 Introduction: the *pro*-knowledge economy outlook

In this second part of chapter five, I introduce the three moral positions on the knowledge economy that share a *pro*-knowledge economy outlook. These positions are weak pragmatist (5c.2), strong pragmatist (5c.3) and third-order capitalist (5c.4). After our consideration of the moral positions, we consider what young scientists had to say regarding the conceptual and practical limitations of the knowledge economy (5c.5), before finally concluding our discussion (5c.6)

5c.2 Weak pragmatist

The weak pragmatists expressed the mildest form of support for the knowledge economy. They composed the second most popular moral position after strong pragmatism: five of the twenty interviewees could be counted as a weak pragmatist. The characteristics of this position are as follows. Firstly, the weak pragmatists all began their PhD with the primary aspiration of becoming an academic. However, uncertainty had set in over the feasibility of this future career, usually at around the second year of the PhD. This experience had undoubtedly opened up the weak pragmatists' thinking about science and scientific careers. However - and this is the second point - their support for the knowledge economy as an alternative to academic science is limited. They maintained that a career in academic science was of superior value and prestige to scientific and other careers outside of the university, and, as will be revealed in chapter six, they made no active exertions to explore alternative career options. They 'hoped for the best'; that best being that they would be successful in their primary ambition of securing an academic postdoc. The third point to note about the weak pragmatists is that their attitude to the knowledge economy is not simply mildly accepting; it is nuanced in the sense that they find fault with some of its aspects. It is plausible that having admitted to starting the PhD with the hope of becoming an academic, many of the weak pragmatists could once have been classified as scientific purists or socially-oriented. Thus, a hostile attitude to certain elements of the knowledge economy is evidence of prior sentiments lingering on. The category of the weak pragmatists further illustrates the extent to which attitudes and scientific identity are changeable through the course of the PhD; indeed, it is unlikely that many young scientists will float around in this rather unresolved position for too long.

The weak pragmatists did not follow the gender and disciplinary patterns seen in the scientific purists and the socially-oriented young scientists. Rather, they were a heterogeneous group; united

by the primary hope of becoming an academic, while hinting at an underlying flexibility in their career plans. All but one of the weak pragmatists were research council funded but then this is not exceptional for the PhD population at this university. The weak pragmatist with an alternative source of funding – Jack, who was supported by the Ministry of Defence (MoD) – stated that his employer had given him a generous degree of freedom, comparable with that of the research council students. As he put it, the MoD wanted his research to be carried out without *‘the boss breathing down [my] neck’*, and a high degree of academic freedom in the PhD was a condition common to, and expected by, the majority of weak pragmatists (6).

The weak pragmatists suggest that the university is largely removed from the spheres of politics, commerce and society. The university scientist is thought to engage little with the outside world. A career in university science is thus considered unique; the purity of its focus is highly desired by the weak pragmatists, even if they realise that career openings are scarce. As doubts over the certainty of an academic career mounted, the weak pragmatists looked to the offerings of the knowledge economy - and unlike the scientific purists and the socially-oriented young scientists- admitted that they could see some benefits in its message. Admittedly, many of these benefits related to its ability to boost the academic sector of scientific research. One of the ways in which it was deemed to have a beneficial effect upon university science was in terms of greater financial investment. For Jack, the economic value of the STEM subjects was inherent and therefore the reasoning of the knowledge economy was not totally inconsistent to the essence of science. He explained that STEM graduates are *‘automatically more numerate... you know how to deal with a problem and you look at things quite rationally’* (16). As such, Jack conceded that they were probably more valuable and well-suited to knowledge economy work than students with *‘other degrees’* (16).

Rosie believed that UK science needed more funding, and hoped that knowledge economy policies meant that UK universities would receive it. She thought that the knowledge economy would prevent a dilution of higher education funding across a broader variety of subjects, cutting down on *‘the degrees that are a bit wishy-washy... Klingon language or something’*; and allowing more money to flow directly into UK science (11). Rosie worried that UK science was losing its young *‘bright minds’* and hoped that as far the knowledge economy implied greater investment in UK science, it could counter this trend. Jack shared Rosie’s perception that a brain-drain was a real threat to UK science, and that the knowledge economy could be one way to prevent this (1). In addition, Jack welcomed the knowledge economy as a way to move the UK from what he saw as an

economic dependency upon *'business and banking'*; moving instead to a focus upon science, technology and invention (1). Rich acknowledged that the knowledge economy would probably entail a good outcome for the university, because an economy that demanded higher education qualified workers would mean *'more demand for universities'* (2). Aside from the financial input and demand that the knowledge economy would mean for UK science, Rosie and Charlie also accredited it with providing an image boost for UK science. As Rosie explained,

You don't want science looking geeky. You find that it does... you don't want it looking like a fusty old place that only really bright people go into. You want it to encompass everyone and say: 'Come study science, it's absolutely fabulous'.

(Rosie: 12)

Drawing from a personal anecdote, Charlie agreed with Rosie's view. Charlie vented his frustration that as a STEM doctoral student, he was sick of being regarded as *'a lounging student'* by his friends (8). This angered Charlie, for he considered his PhD to be a job. He explained, *'I view it as work... I go in every day, at least nine to five'* (Ibid.). He hoped that knowledge economy might be one way to demonstrate to non-scientists that being a STEM PhD student is comparable to a full-time job, and it should command equal respect.

If anyone asks me how's my PhD going, it's always with a tongue in their cheek saying, when are you going get a real job, when do you want to get out of education? So, if you can change that perception... maybe the knowledge economy is a way of doing that.

(Charlie: 2)

Ostensibly, there is a sense in which Charlie's ability to see a positive potential in the knowledge economy arises in his understanding that as a framework, or narrative, it might enhance society's appreciation of academic science. He does not go so far as to contemplate how the knowledge economy might actually change academic science. For Charlie, the appeal of the knowledge economy concerns what it can do to better the image and representation of science in society (11).

Despite their acceptance of certain aspects of the knowledge economy, the weak pragmatists demonstrated very little evidence that they conceived of their PhD as preparation for the knowledge economy. They struggled to see how they would fit into the knowledge economy; so although they

conceded that other young scientists might, this stance reveals that the weak pragmatists' tolerance of the knowledge economy is general and not personal. Rosie, for example, used her age, and status as a mature student, to exclude herself from the knowledge economy. She reasoned: *'It's not really sort of affected me. Maybe if I was 20 years younger it might have done'* (12). Jack doubted that the knowledge economy would be an ideal choice for him because of his felt need for freedom in research; an extent of freedom that he thought only academia could offer. He explained, *'doing a postdoc would be brilliant because you'd just get into your work and get to do what you wanted'* (14). Rich agreed that most PhD students start their research hoping to become an academic, *'a year or so in you suddenly sit up and realise: 'Hang on a minute, there's 30 to 40 people here, scrambling around for one professorship. My odds aren't great'* (2). Given the competitiveness of this situation, Rich could see that the knowledge economy was one way in which aspiring scientists could stay in research albeit in a space other than academia. The mismatch between the *'growing PhD population'* and the size of the academic community troubled Rich; he worried that there were not enough suitable *'career options for people to go on to'* (15). Thus the knowledge economy was one way to ensure that this PhD talent was not wasted. Rich's support however stopped short of bearing influence upon his personal career ambitions. Indeed, by the time we met for an interview, he had just the day before started a postdoc at another research-intensive university. His acceptance of the knowledge economy clearly went further than the scientific purists or the socially-oriented young scientists, but as with the other weak pragmatists, he ruled it out as a personal option.

Laurie was the only weak pragmatist who had come to think he probably would leave academia after his PhD. Notably, he did not present this as a matter of choice. Rather, it related to his desire for financial security and his belief that an academic career could not provide this. He spoke of his felt duty to care for his elderly mother, and how it seemed selfish to focus only upon academia when he *'[could] go and work for a bank because they're willing to pay me £90,000 to do some boring data processing thing'* (12). Nonetheless, even when faced with this temptation, Laurie upheld the weak pragmatist view that knowledge economy work was less desirable than academia. For Laurie, only academia could promise the level of interesting work that he had come to expect and enjoy in the PhD. As he explained, *'a lot of people refuse to work for banks on moral grounds. I don't care about that. It would just be really, really dull'* (12). The knowledge economy narrative, which promises to offer well-paid autonomous and creative work had clearly not succeeded in convincing Laurie that it is academia's equal. Laurie's comments are insightful because they

suggest that when morality is not an issue, young scientists may continue to reject knowledge economy work if it is not deemed to be interesting enough. In a similarly passive manner, Charlie – after naming an academic postdoc as his first choice career option – toyed with the idea of science communication as an alternative vocation (7). Yet still he made it clear that he considered science communication as something of a contingency, and in contradiction to his comments that more needed to be done to remove the perceived fissure between science and society, he believed that pursuing a career in science communication would only occur if he were to leave science proper. Thus, the implication in Charlie's comments is that proper scientists do not do science communication (7). For the weak pragmatists, that the knowledge economy might be in part a positive development is permitted; but at the same time, it is not judged to be a serious option for them personally. Other PhDs may move into it, but the weak pragmatists remain hopeful that for them, an academic path will work out.

It is evident therefore that the weak pragmatists privilege academia as the optimum site in which scientific knowledge production should take place. Their understanding of the university remains, in many ways, modern. It is subsequently unsurprising that the weak pragmatists criticised elements of the knowledge economy that they thought either encroached too far, or distorted, the hallowed space of the university. One basis for this criticism was rooted in the belief that politicians were untrustworthy. Rich claimed that he was yet to see a vision of the knowledge economy fully worked out, and Jack had little confidence that political rhetoric could be matched with real policy (Rich: 17; Jack: 1; Charlie: 8-9). More precisely, Jack worried that the knowledge economy as a framework could easily be used to conceal more politically expedient purposes – namely the drastic cutting back on publicly funded research (2). While an increase in university-industry collaborations and privately funded research was not rejected outright by the weak pragmatists, they dismissed the idea that it could replace the public funding of basic research. Echoing the argument of Friedrich von Hayek outlined in chapter two, the weak pragmatists understood basic research to be non-rivalrous in essence and unpredictable in terms of its propensity to yield a profit. Thus for the weak pragmatists, it is an axiomatic condition that university science cannot be wholly funded by private industry (Charlie: 4; Laurie: 2; Jack: 2). Laurie worried that the knowledge economy would remove the necessary room for serendipity in scientific research, reasoning '*we've invented all sorts of fantastic things by accident and at the moment a lot of people are being pushed to do things that they can immediately justify*' (2). For PhD students in particular, Jack struggled to see how corporate funding only would work.

I don't think you can expect the private sector to fund things if they don't know if they're going to get something of it. I can't really see how that would work. For them to say: yes, you do a three year PhD and we'll see what happens, I can't really imagine it.

(Jack: 3)

In light of the fact that he was funded by the MoD, Jack did go on to admit that industrial involvement could sometimes work well, giving the student ‘*more focus... a bit more purpose to things*’ (3). However, for this to work he believed that industry had to take a step back and have a good understanding of academia (6). On the basis of his observations as a PhD student, Jack had all too often seen industrial involvement in PhDs go wrong.

I've seen examples where it's just completely ruined things. I think it only takes one person to stick their oar in to just completely destroy things. I've seen people... work on something for two years and suddenly they'll say: 'Oh we're not interested in it'. That's just painful.

(Jack: 8)

In addition to Jack’s criticisms, Rich remained unconvinced that academia was a suitable place for industrial knowledge production, or that academia provided a suitable training ground for researchers who planned to forge a career in industry. On the contrary, Rich believed that ‘*as for preparing you to work in industry, three years working in industry would be a better way to prepare for it*’; and saw affirmation of his view in the complaints of UK employers who continue to state that STEM graduates are not industry ready (14-15). Laurie upheld the dichotomy between academia and industry and admitted he was against attempts to bring them closer together. As he explained:

I went and worked at a nameless large corporation for six months as part of my undergraduate degree and hated it. I absolutely hated it. It was the exact opposite of [the university]; the least enthusiastic talented young group of people. I did a PhD to stay away from that for a few more years.

(Laurie: 3)

So for the weak pragmatists, personally accepting a role in the knowledge economy would be difficult, and far from ideal. Furthermore, they believe that the knowledge economy should be kept separate and distant from the site of the university. Given their praise of academia vis-à-vis the knowledge economy, it is likely that they would experience feelings of inadequacy and stigma if they were unsuccessful in securing an academic career. However, it is important to remember that they have already undergone a transformation of a kind; and that they are far more open to the possibilities of the knowledge economy than the scientific purists or the socially-oriented young scientists. It is therefore possible that should they find themselves working in the knowledge economy in the future, they may undergo yet further change in their scientific identity, assuming the position of a strong pragmatist or a third-order capitalist, which are more supportive of the knowledge economy.

5c.3 Strong pragmatist

The moral position of strong pragmatism attracted the largest number of the young scientists. Where the weak pragmatists accepted the knowledge economy, but held that it was secondary to an academic career; the strong pragmatists considered academia and the knowledge economy to be equals. Like the weak pragmatists, they had begun their PhD in most cases with the hope of becoming an academic, but they had suffered a far more extreme shaking of their confidence once confronted with the reality of academic life, and the probabilities of securing a postdoc. Unlike the weak pragmatists, who remained hopeful that an academic career would work out, the strong pragmatists were beginning to consider seriously the prospect of working in the knowledge economy. Thus, no doubt in order to protect the coherence of their scientific identity, they asserted that the knowledge economy was on a par with academia in terms of desirability and prestige. Furthermore, as will be evidenced in chapter six, the strong pragmatists were active where the weak pragmatists were passive; in other words, they had begun to scope work opportunities in the knowledge economy and think about how they might best apply their skills and knowledge to it. It follows that while the strong pragmatists did not claim that the knowledge economy was wholly perfect, they were far less vocal in identifying its shortcomings than the weak pragmatists.

The strong pragmatists provide a slightly neater classification than their weak counterparts. Only one was female – Isabelle, who was an engineer. Engineering was the most frequent discipline across the strong pragmatists; being an applied subject, it is easy to see how thoughts of working in an industrial setting in the knowledge economy did not present too much a problem as far as

scientific identity was concerned. The three exceptions were George and Simon – mathematicians, and Thomas – a physicist. These three young scientists represent quite extreme cases because they had ruled out an academic career in absolute terms. As will be shown, thoughts of personal ability and suitability mattered more in the planning of their scientific careers than discipline. Simon was not confident that he could forge a successful academic career; whereas Thomas and George had experienced some bitter times during their PhDs, resulting in an open-minded appreciation of how they might continue to work as scientists outside academia.

The strong pragmatists uphold the same modern view of the university as the scientific purists and weak pragmatists. For the strong pragmatists, university science follows a detached and narrow focus; its removal from politics, economics and society means that only a privileged elite can forge a lifetime career within it. For a variety of reasons, the strong pragmatists question whether they are likely to join this elite, and have thus begun to broaden their gaze to alternative postdoctoral careers. The strong pragmatists recounted that although they had started the PhD with the ambition of becoming an academic, serious doubt about this decision set in, usually after the first year. Mathematician Simon was the only interviewee to contemplate the possibility of not completing his PhD. Simon clearly lacked confidence in his abilities as a doctoral student, and this insecurity had been compounded with other troubles, such as his supervisor leaving in his first year (3). Simon's failure to envisage his future self as an academic researcher must undoubtedly have made the contemplation of other vocational identities far easier, than for the scientific purists or socially-oriented young scientists who could not imagine *not* becoming academics. He had a far more fluid approach to his scientific identity, explaining that he remained '*undecided*' about his post-PhD career and that it would '*depend where my head is in a few years*' (6, 11). At the time of our interview, engineer Isabelle had secured a postdoc at Cambridge, but with the experience of job hunting a recent memory, she appreciated how '*hard [it was] to get a research job in a university*' (10). Daniel's PhD experience indicates not only how hard it can be to get a research job in a university, but similarly, how hard it is to come to terms with this. He shared his personal moment of realisation, and how difficult he found this to deal with.

I always used to think the PhD was preparing me for an academic career in science. I actually don't think that at all anymore. [Coming to terms with this] is really, really hard, and I had a lot of issues with it. I came in thinking I was going in that direction, to

be an academic. I now don't have a clue what I'll be doing afterwards; I really don't know.

(Daniel: 6)

Reflecting on how this moment of realisation occurred, Daniel referred to *'how small the pool of academics is; also, what comes into this is the intense competition that goes on as a result... At times it's so brutal'* (6). Thus it was the type of environment created by the intense competition for an academic career, and not just the competition itself, that had turned Daniel away from academia. Fellow strong pragmatist Thomas identified the tribulations and stress of his PhD as the reason for his conversion to strong pragmatism. Thomas was in his third year at the time of our interview, and extremely frustrated with academia and his university more specifically. His lab had been closed during his PhD, changing its topic and giving him a feeling of helplessness, and he was less than impressed by the university's responsiveness to researchers' needs. He also disliked the perceived hierarchy involved in academia; referring to it as a *'gravity train'* – an inflexible mode of organisation that tended to stifle the *'creativity, energy and dynamism'* of young scientists (10). Dylan agreed that a perceived lack of meritocracy in academia had been the main cause of his doubt. He did not see himself as the kind of *'political'* person that one needed to be to excel in academia, and he compared it unfavourably with a career in industry. He contrasted the perceived simplicity of forging a successful career in industry, against the uncertainty and additional burdens of academic life.

I don't really need to think too hard about this. I just work hard, make money and then I'll get promoted. In academia, to me it seems like there's like this tug of war. It's not entirely clear to me how you get promoted and the way I see it, it could be wrong, it just seems it's who you talk to, what you say to people - this is how you get promoted.

(Dylan: 10)

Mathematician George had decided against academia also for personal reasons. His main concern was not whether he was intellectually gifted enough, but that his personality simply did not fit. He explained, *'it's my need for others that makes me think I can't stay in academia'* (9). George viewed his PhD as the occasion to think long and hard about the demands of academic life.

Are you passionate enough about this, do you have this odd drive? Are you a broken person that will just stay in the department all the time, ignore your family? [The PhD is] freedom to stare into the abyss and face down your demons and work out if you are the kind of person that can do this or not.

(George: 8)

The certainty of his decision to walk away was reinforced by events witnessed through the PhD: ‘*dear friends who have fallen by the wayside*’ (11); and that ‘*quite a lot of my friends are either on anti-depressants or they’ve quit*’ (5). For George, the knowledge economy is not simply an equal alternative to academia; it provides an opportunity to develop his PhD knowledge and skills in a scientific career that is far more conducive to his understanding of a healthy work-life balance.

As the prospect of an academic career became seen as increasingly unlikely – or undesirable – for the strong pragmatist, there was a correspondent elevation in the perceived attractiveness and feasibility of knowledge economy work. Simon, for example, had worked for one year in a pharmaceutical company prior to his PhD, and he was confident that should he return there after attaining the qualification, his contribution to scientific research would be no less than if he were to stay at the university (6). Daniel looked favourably to the knowledge economy for his future scientific career, and expressed his relief that, given the scarcity and competitiveness of academic positions, ‘*I don’t need to go down that road*’ (6). He believed that his PhD had prepared him well for a move into the knowledge economy, and he began to think of himself as a scientific ‘*researcher*’ who could work in a broad range of contexts (5-6). This fluidity, and the subsequent unknowns brought with it, did not alarm Daniel. He explained:

It’s not a negative thing. I’ve got so many more ideas and doors to open. I could stay in academia; head off to do industrial work, or some other sort of technical or scientific work. I can see myself heading in many directions and I never thought this would be the case.

(Daniel: 6)

Dylan was similarly confident that his PhD made him extremely employable in the knowledge economy. He admitted that he felt ready for ‘*the corporate world*’ (12), describing his analytical

skills developed through the PhD. Indeed, he concluded that this had been the purpose of his PhD - *'preparing me for an R&D career'* – and not an academic one (12).

After an unpleasant first taste of academia, and the stress caused by his lab closure, Thomas agreed that *'I just want to get a job in the, as my mum would call, real world'* (3). Echoing Daniel's metaphor, Thomas described the *'door'* of the knowledge economy as being open to him, and he expressed confidence that the qualification of the STEM PhD equipped him to exceed in the knowledge economy (9). He admitted also that the financial lure of the knowledge economy was far more tempting than what he perceived to be the somewhat more tedious option of *'just more academia'* (13). George was less sure than Daniel and Dylan that his PhD left him specifically trained for the knowledge economy, choosing to describe his area of mathematics as *'aimless and insane'* (George: 10). Nevertheless, since he was very doubtful that he would stay on in academia, he reassured himself that his tenacity for hard work – a capacity tested and developed through the PhD – would stand in him good stead to find knowledge economy employment. Reflecting on the transferability of his skills, he explained, *'I'm not scared of learning anything, basically. [The PhD] has made me slightly fearless and confident in my ability to learn'* (9).

Although Isabelle had managed to secure her first postdoc, she indicated that the knowledge economy provided an equally desirable space for young scientists to move into, and she urged knowledge economy stakeholders to better communicate this message.

If you say to prospective STEM PhDs, you can either go into the academic arena, or – and this what the government really want you to do – you can go into the knowledge economy, into industry, and there will be good provision, and you will get paid really well and it's an equal, really good option, then I'm sure that many more people would do a STEM PhD but with this in mind.

(Isabelle: 10)

The problem at the moment, she acknowledged, is that young scientists' ignorance of the knowledge economy, combined with a lack of transparency from politicians and industry, meant that young scientists might think of it as *'a bit sinister - through the back door sort of thing'* (10). For Isabelle, this implied a misunderstanding on the part of young scientists, and she hoped that politicians and industry would act to address it. It is evident that the strong pragmatists looked

towards the knowledge economy with hope and high regard; moreover, it will become clear in chapter six that they had also begun to shape their PhD in order to prepare themselves for it.

The strong pragmatists not only saw the knowledge economy as providing a lucrative option for their own scientific careers. Benefits for the university and science more generally included opening up the meaning of what it is to have a scientific career (Simon: 11); enabling universities to diversify their funding sources and enjoy greater autonomy from the state (Daniel: 4); providing more funding for PhD studentships and providing a greater 'mix' in the types of PhDs on offer (Isabelle: 3; Dylan: 4); and forging closer relationships between universities and industry, which could in turn boost students' employability (Thomas: 2). However, it is important to note also that the strong pragmatists were not quite as supportive of the knowledge economy as the third-order capitalists. Some scenarios of its possible development worried them.

Simon asserted that offering more STEM PhD studentships would only work if students were committed and passionate (Simon: 10). If they weren't, it would be a wasted investment and the UK knowledge economy would not reap any benefit. A significant concern related to the protection of academic freedom, and guarding against too much knowledge economy influence creeping into the domain of academic science. Isabelle believed that companies often push scientists to achieve certain results (4); Thomas worried about a possible over-politicisation of science (2); and Dylan feared that '*certain avenues of research*' may be stifled if private interests had too much say in dictating the academic research agenda (3). Cost-cutting and a drive for greater efficiency formed a related concern for Daniel, who expressed his contempt for doctoral training centres – or '*PhD farms*', as he labeled them – which, contrary to the EPSRC vision of the model encouraging peer to peer learning and research, he believed would destroy the traditional apprenticeship model of one-to-one PhD supervision, and therefore cause great damage to the quality of '*skills and training*' that a PhD student would develop (EPSRC, 2012; Daniel: 2; 12). Dylan worried that the knowledge economy narrative might cause some PhDs to get overly distracted by thoughts of commercialising their research – at the expense of producing a high-quality academic PhD, explaining that '*just because you're doing a PhD and you're bright... I don't necessarily think that it means that you have good business skills*' (5). In a similar vein, George derided the '*financial mathematicians*' with whom he shared his office:

A lot of them have come in to get a certain kind of training because they're looking to work in investment banks. You've got all these people coming in wearing blue shirts and treating it very much like an MBA and less like the pursuit of academia.

(George: 4; 6).

Thus, the strong pragmatists continue to uphold the academia versus industry distinction – as per modernity and the other moral positions formerly discussed. The difference setting this moral position apart from the others is the belief that academia and the knowledge economy are equally respected – if separate - sites in which to conduct science. On an individual level, it is thus morally tolerable for the young scientist to move between academia and the knowledge economy; and if they were to do so scientific integrity would not necessarily be compromised.

5c.4 Third-order capitalist

At the extreme *pro*-knowledge economy end of the moral spectrum are the third-order capitalists. The four students who fitted the third-order capitalist category proposed that the knowledge economy provided a superior framework of organisation for science than academia; they believed that academic science should be subordinated to, and directed by, the agenda of the knowledge economy. The classification of 'third-order capitalist', refers to Steve Fuller's assertion that the knowledge economy is '*capitalism of the third-order*' (Fuller, 2003: 103). In selecting this description, Fuller sought to emphasise the extent to which the knowledge economy is the latest advent of capitalism's drive for profit-making. The third-order capitalists welcomed the knowledge economy as the most recent expression of capitalism, and they shared the view of its proponents that science should be recast as a site of economic capital, rather than simply knowledge, production.

The third-order capitalists share the view of the scientific purists; that the university is an institution completely detached from political, financial and public concerns. Conversely however, it is for this very reason that they desire to forge their postdoctoral careers outside of it. Not only were the third-order capitalists positioned at the opposite end of the moral spectrum to the scientific purists in terms of understanding of the university, and attitude towards the knowledge economy; they also possessed diametric personal characteristics. Most notably, the third-order capitalists were all male, and likely to originate from the applied sciences; three being engineers and one a computer

scientist. The applied nature, and private-sector association, of these disciplines no doubt made acceptance of the knowledge economy a far easier matter for these students. Indeed, it is arguable that for a UK-based engineer or computer scientist to problematise research focused on real-world problems within the corporate sector would be far more surprising, and suggest an inconsistency, with the basis of their respective disciplines.

The third-order capitalists also had work experience prior to starting the PhD, and it was likely that this would have been outside academia: investment banking, electrical components and computing being the cases here. Three of the four third-order capitalists asserted that they entered their PhD with this moral position in place. Thus, for those who had begun to doubt their progress towards securing an academic career, transition to this moral position was far less likely than a move towards weak or strong pragmatism would be. However, this is not to say it was impossible. One of the third-order capitalists; Mohammed, started his PhD with the sole aspiration of becoming a university scientist, and he counted working as a university research assistant as his only work experience. Nonetheless his PhD experience had amounted to him giving up on his academic dream and taking up the position of a third-order capitalist.

All the third-order capitalists foresaw a career outside of academic upon completion of their PhD. They wanted to stay in research, and so industrial R&D was deemed to be the most desirable option (Will: 10; Graham: 9; Toru: 7; Mohammed: 12). Toru, a medical engineer, was prepared to go to America to forge his R&D career, since he believed that US employers valued the PhD more than UK companies did. The belief that UK employers under-appreciate the PhD was shared by Graham, who commented that, although he intended to return to industry, *'I suspect the PhD will not be a factor in me getting a job or not getting a job'* (5). He held this view because, like Toru, he believed that UK employers did not see the value of a PhD qualification outright. This did not overly trouble him however, for he expected that on securing a job, he would excel in his profession faster than if he did not have a PhD. Will's experience in industry also gave rise to the impression that UK employers did not hold a high degree of confidence in candidates with PhDs. He recalled that his *'first boss didn't value PhDs because they were too narrow'* (6). The level of specialisation entailed in the PhD led to speculation from employers as to whether individuals with PhDs would be able to successfully make the move into the more broadly-focused world of work. Although Will was registered as a full-time PhD student, he continued to have a role in his former company. He described how he had recently employed *'a Maths PhD student'* in this capacity, a decision that he

described as *'risky'* (6). There was, he admitted, an understanding that he would need to *'shake him out of what he was'* (6). Thus, in Will's comments, there is a clear suggestion that academia, and the PhDs that it produces, are not deemed by employers as knowledge economy ready. Toru and Graham, with their industry experience, seemed aware of this, and anticipated a period of possible adversity, having to prove themselves, and proactively seeking work in order to secure their idealised knowledge economy work. More optimistically however, they did expect employer attitudes to change. As Will and Toru noted, the knowledge economy is deemed to be a global phenomenon (Will: 1; Toru: 1). If this is truly so, Toru reflected, then UK employers must start to entice and retain home-grown PhDs with far greater success than at present. The future of the UK's economic competitiveness rested upon its transition into third-order capitalism.

The third-order capitalists saw no issue in articulating a positive relationship between higher education and earning potential. On the contrary, this relationship was central to their set of beliefs, and they saw emphasis of it as only a good thing. It is possible that the UK's economic recession had influenced this perspective and encouraged an attitude towards higher education that was undeniably rather mercenary in nature. Toru admitted that he saw the PhD as a personal financial investment. He had been made redundant from his job at an investment bank before deciding to start it and in somewhat contradiction to his feeling that UK employers in general did not value the PhD qualification enough, he explained how the following experience had been decisive in his reasoning to enroll.

I used to work for a bank, and [it was] very competitive...I felt I was under-qualified in my team because there were about 15 of us and I'd say 9 people had a PhD. None of those people were made redundant. I was made redundant.

(Toru: 2)

Toru believed that he was not alone in such thinking. Other ex-colleagues who were made redundant had pursued Master's degrees with a similar mindset, and Toru observed how in this time, tuition fees had risen. Some, he documented, had moved to America, where they *'were paying something like \$60,000 for a master's course'* (Toru: 2). For Toru, such a trend amounted to concrete evidence of the rise of the knowledge economy. Higher education was in great demand, as these individuals *'pursue knowledge to strengthen their bids [for work]'* (Toru: 2). Toru's account has clear resonance with Steve Fuller's identification of *'credentialism'* as a symptom of the

knowledge economy, whereby individuals seek to attain higher education qualifications not necessarily to acquire new knowledge but to merely formalise their intellectual assets, within a labour market wherein the tangible demonstration and recording of knowledge is the most significant means of differentiating between workers (Fuller, 2003: 111).

The third-order capitalists valued the STEM PhD insofar as it prepared them for entrance into the knowledge economy. They defined and valued knowledge in terms consistent with Michael Gibbons et al.'s mode 2 classification. Hence, they prioritised application, connection to real-world problems, patents, commercialisation, profit-making and interdisciplinarity, in the scientific knowledge produced in their PhD and future career. The current model of the PhD however, does not stipulate that any of these criteria are met in terms of knowledge production. For Will, this vastly undermined the value of the scientific knowledge produced in the PhD, which in turn affected the sense of achievement a PhD student of the third-order mindset could experience. Successfully meeting a deadline, or submitting a paper made little cause for celebrations he explained: *'you don't really feel happy because haven't really done anything'* (4). The non-disciplinary specific critical thinking developed through the PhD was however highly valued by the third-order capitalists, since they understood that this ability would prepare them to conduct science in a plethora of different contexts and disciplinary areas after the PhD; accordant with the image of the multidisciplinary, reflexive profit-maximising worker that is so desired in knowledge economy orthodoxy (Mohammed: 10; Graham: 9). Toru admitted that many of his former colleagues had questioned his choice of a PhD in medical engineering. For him however, subject matter was almost irrelevant in terms of how the PhD would prepare him for the knowledge economy.

A lot of my friends who still work in the finance industry thought it was quite a bad move. They were like, 'Why did you do Medical Engineering?' Half my reason of doing a PhD is to go through the process of how you gather information; how you assess what's good and what's not, what's useful... basically it's problem solving. I didn't think it would be too important what subject I did; as long as it was something I was interested in.

(Toru: 4)

Interestingly, Toru's comments reveal a further characteristic of the third-order capitalists; that no matter how committed they may be to leaving academia and pursuing knowledge economy work,

they must, for the duration of the PhD, remain sufficiently interested and conscientious in order to successfully complete it. Thus, there is no suggestion here that the third-order capitalists need necessarily produce a STEM PhD judged to be of a lower intellectual standard than say the academia-committed scientific purists. Their post-PhD plans may involve an abandonment of academia but that does not mean they can afford to be half-hearted in their commitment during the PhD. However, at the same time as ensuring they meet academic standards, it will be evidenced in chapter six that the third-order capitalists actively shaped their PhD in a way that they thought would prepare them for the knowledge economy.

At the time of the interviews, the third-order capitalists berated UK universities for not being optimally suited for the knowledge economy. For a start, they thought that universities were not producing an adequate amount of mode 2 knowledge; the type of knowledge that they valued. Academia remained governed by the pressure to publish, and for the third-order capitalists, the scientific knowledge published in academic journals was *not* mode 2. Rather, it was bound to traditional mode 1 disciplines and involved the answering of smaller problems - or worse still, as Will believed, '*not actually solving the problems... just publishing stuff*' (Will: 3). An exasperated Will couldn't understand why academic problem-solving seemed to be so detached from the problem solving of the corporate world.

The fact that a PhD student spends a year possibly finding a problem I find funny. I go into my company: there are problems every single day. But yet you have PhD students finding problems.

(Will: 5)

The present gulf between academia and industry was highlighted, and the third-order capitalists lay most of the blame for this distance at the door of the university. Their consensus was that academia needed to change. To use the term of Gibbons et al., the university needed to evolve in order to fit with the new institutional landscape that mode 2 knowledge production requires (Gibbons et al.: 147). Or, to refer to the work of Etzkowitz and Leydesdorff introduced to us in chapter two, the third-order capitalists thought that the triple-helix model was not yet in place, with the onus being placed primarily upon universities to evolve in order to realise the triple-helix arrangement. Mohammed believed that the government could also assist in providing the incentives to lure UK scientists into mode 2 knowledge production. For example, he questioned why contracts for

publicly funded projects did not stipulate that bids would be judged in terms of innovative design, application and commercial value. This, he thought, would force academics to come up with bolder plans that addressed the nature of mode 2 knowledge (15).

It was also agreed that the UK government needed to invest greater amounts into the country's R&D sector. At present, the third-order capitalists had little confidence in this financial injection happening; this distrust is discussed in the next section (5c.5). Trust in politicians was generally low, as Graham conceded. While he supported the knowledge economy in principle, he was unsure whether politicians' rhetoric would amount to a tangible reality. '*As far as it implies a load of politicians standing up and saying vacuous applause words it's not the most interesting thing*', he lamented (11). Mohammed believed that in addition to poor financial investment, the UK did not bestow enough respect upon scientific professions. He compared the engineering profession unfavourably with the respect demonstrated for it in other nations (5). Graham agreed on this point, remarking: '[In the UK], *science and engineering are almost seen as a failed profession. If you're not working in banking or football you're looked down on*' (11). Graham hoped that political emphasis upon a burgeoning knowledge economy could help to change these attitudes. For Mohammed however, one of the main reasons that undermined his confidence in the UK government's capacity to play its part in fostering a knowledge economy stemmed from the lack of representation of scientists in UK parliament (9). Mohammed believed this must greatly impair the UK's knowledge economy policy and planning.

Criticism of the government aside, universities presented the greatest source of discontent and most complex challenge in building a knowledge economy. This is because not only did they appear to the third-order capitalists as reluctant to commit to the knowledge economy financially, they were also regarded as being culturally antithetical to it. Mohammed and Will in particular decried the lack of financial investment of UK universities, manifest in non-industry standard research equipment, which they agreed impeded young scientists' chances of securing work in the knowledge economy. As Will bemoaned, universities' lack of industry standard tools made the experiments of young scientists '*more painful*' and their training less relevant for the knowledge economy (Will: 4). Mohammed worried that some of most able young scientists would be put off from studying for PhD by old computers and '*broken keyboards*' (16). The negative implications of such mal-investment could hardly have been put more strongly by Mohammed, who felt that the quality of scientific research would suffer, and it would turn many students, like himself, away from

a career in science, since it propagated a message of poor prospects and institutional apathy. Mohammed explained that he was living proof that the condition of the university research environment could transform career trajectories: *'There is no way in heaven I want [a] scientific career; I just want to stay out of it'* (16).

Perhaps of greater concern was the cultural gap between the university and industry. As Will proclaimed, *'these are very, very different worlds'* (5). Academics were accused of being out-of-date, irrelevant and arrogant; living too comfortably on public expenditure while not offering much back to society. With clear outrage, Will found the notion that academics were unwilling to engage in public communication appalling (8). Furthermore, as I have already noted, academic publications in particular were dismissed as an out of touch measure of scientific knowledge and funding allocations. This judgement would correlate with the broader knowledge economy trend documented in Castells and Gibbons et al., that modern communications - primarily internet networking - rather than libraries and journals, are set to become the key conduits for knowledge transfer (Gibbons et al.: 131). Will concluded that academics must be *'extremely selfish'* if the only motivation driving their work was to see their name in print (6). This belief created further anger in light of the perception that PhD students were often only enrolled to boost an academic's publication record (Will: 11; Mohammed: 8; Toru: 8). I will explore this attitude further in chapter six, but for the purpose of our present discussion, it serves to highlight that the third-order capitalists view the academic community as self-interested and insular; a community to which Latour and Woolgar's scientific credit cycle model would seem to apply perfectly - if it were not for the third-order capitalists who despite composing a temporary part of it, plan to leave the community and rebel against some of its rules whilst there. The third-order capitalists' professed intent to shake up the protocol of university science suggests that they prized highly knowledge transfer and the falling away of the traditional boundaries between university, industry and state. In other words, they look to the future with hope that a triple-helix model will emerge. Meanwhile however, Will described his frustration with the lethargy that he perceived as endemic in UK universities.

Coming to university; there's no energy. If I go to work, yes, most people might be quite stupid, but there is an energy. Coming here, there's not as much intellectual energy as what I was expecting.

(Will: 6)

A further issue of condemnation was UK universities' lack of interest in forging relationships with industry (Will: 2, 12 16). Mohammed criticised the high overheads that his department had chosen for consultancy research, saying that this deterred the university-industry partnerships that could give him invaluable experience (2). The financial and cultural distance between UK universities and the knowledge economy greatly angered the third-order capitalists. After all, they were committed to their PhDs only on the condition that they were being prepared for enhanced prospects in the knowledge economy.

It is clear that the third-order capitalists found many flaws in UK academia and that they believed the STEM PhD suffered because of this. However, they agreed that despite opportunities for improvement, the STEM PhD remained the preferred model for training scientists. It is noteworthy that no third-order capitalist expressed regret at undertaking the PhD, or believed that an alternative experience could prepare them as well for the knowledge economy. Suggestions for improving the PhD experience included greater emphasis on the communication of research, and experience of pitching ideas to industry, industrial placements, less attention on the publication cycle and less pressure to publish. Third-order capitalists also thought that applying the latter two suggestions to academia more generally would lead to its marked improvement. The third-order capitalists embraced the knowledge economy, and they believed that UK academia would be much improved by adapting to serve it. Graham mused '*how could it be bad?*' (2); and Mohammed, in more forthright terms, declared that it should become '*the law of the land*' (17).

In table 5.4 overleaf, the main points of difference between the five moral positions are summarised.

| <i>Scientific Purist</i> | <i>Socially-oriented</i> | <i>Weak pragmatist</i> | <i>Strong Pragmatist</i> | <i>Third-order capitalist</i> |
|--|---|---|--|---|
| Knowledge is valued for knowledges' sake | Knowledge is valued for knowledges' sake and society's sake | Knowledge for knowledges' sake is best; knowledge for the sake of society and the economy permitted | Knowledge for knowledges' sake, and knowledge for the sake of society and the economy are valued equally | Knowledge for the sake of economic growth is best |
| Academia develops disinterested scientific knowledge from the site of the university | Academia develops socially useful scientific knowledge from the site of the university | Academia develops disinterested science from the site of the university. Socially and economically useful science occurs outside the university | Academia is part of scientific knowledge production. Socially and economically useful science is produced outside the university also. | Academia develops ineffective disinterested science. Socially and economically useful science occurs outside the university |
| External interests threaten the development of pure science | Social interests benefit the development of science | Science has a role in furnishing social and economic development, but academic science is normally distinct from these external interests | Academic science is complemented by economic and social interests; broadening the remit of science opens up opportunities for scientists | Economic interests benefit the development of academic science |
| Academic science is progress | Socially useful science is progress | Academic science is progress | All science is progress | Economically useful science is progress |
| The PhD is a low risk academic apprenticeship | The PhD is a low risk academic apprenticeship | The PhD is a medium risk academic apprenticeship | The PhD is a high risk academic apprenticeship; but it prepares scientists for the knowledge economy | The PhD is high-risk as an academic apprenticeship; it is a knowledge economy apprenticeship |
| Aspire to become a university academic | Aspire to be an academic producing socially useful knowledge | Aspire to become an academic | Aspire to become either an academic or a knowledge worker | Aspire to become a knowledge worker |
| Position is associated with females working in the pure sciences, with experience in academia or the public sector | Position is associated with females working within the pure sciences with diverse work experience | Position is associated with researchers of both genders, across a range of disciplines and with diverse work experience | Position is associated with researchers of both genders, across a range of disciplines and with diverse work experience | Position is associated with males working in the applied sciences, with work experience in private sector industrial R&D |

Table 5.4 The main points of difference between the five moral positions

5c.5 Young scientists on the limitations of the knowledge economy

‘Most institutions demand unqualified faith; but the institution of science makes skepticism a virtue’.

Robert K. Merton (1957)

Many of the young scientists voiced critical analyses of the UK knowledge economy; which, in contradistinction to their moral positions, related not to whether the knowledge economy was a good or bad phenomena, but to what extent it could be said to exist. Exactly half of the interviewees described what they thought to be limitations of the UK knowledge economy; indicating skepticism over whether the political narrative reflected reality. These ten interviewees were distributed across four of the five moral positions; interestingly, the three scientific purists did not express concerns about the feasibility of the knowledge economy, and the third-order capitalists all expressed criticisms.²⁹ It is plausible that the scientific purists avoided a discussion over the existence of the UK knowledge economy in order to substantiate their rejection of it as relevant to their scientific life; conversely, the third-order capitalists are perhaps more predisposed to finding shortcomings in the present state of the UK knowledge economy since they revere it as a solution for improving UK science.

For those students who problematised the assumed existence of the UK knowledge economy, their moral position toward it can subsequently be understood as hypothetical. These students’ moral judgements on the knowledge economy were constructed from their understanding of what it is *by definition*. Put another way, the five moral positions represent a normative reaction to what the interviewees’ think the knowledge economy is *in theory*. In this section, we cast an eye upon young scientists’ critical appraisals on the real-world policies and institutions of the knowledge economy. These young scientists discussed the knowledge economy with a distinction between narrative and reality firm in their mind. Thus, they spoke of the knowledge economy as though it was yet to be fully realised; instead presenting evidence that, contrary to the policy rhetoric, certain supposed symptoms of its condition had failed to manifest.

The examples of critical analysis reported in this section are perhaps unremarkable given that I am dealing with young scientists. It would arguably be concerning if these young scientists were

²⁹ The ten interviewees who expressed criticism over the UK knowledge economy were: Simon, Isabelle, Jack, Laurie, Will, Mohammed, Toru, Graham, Rosie and Rachel.

content to confirm their full confidence in a phenomenon that is new, partially understood and in possession of self-evident shortcomings. By deeply questioning the existence of the knowledge economy, the interviewees implicitly demonstrate the impact of their PhD training, and their adherence to a degree of critical analysis that is characteristic of the scientific method. As the quote from Robert K. Merton indicates, the practice of ongoing questioning is deemed to be the mark of the good scientist. Alternatively, we can say that the Mertonian norm of skepticism continues to be highly regarded by contemporary young scientists. The effect of this ongoing critical inquiry is that the young scientists' moral positions on the knowledge economy remain open to change over time – a point which reminds us of the dynamic propensity of the hermeneutic circle.

5c.5a Human capital

In chapter two of the literature review, the assumption underpinning the political vision of the knowledge economy was outlined. To restate, it is as follows: greater input - human capital and investment in techno-scientific knowledge - will lead to greater output - technological application, innovation, product and profit. As the interviewees' criticality towards the existence of the UK knowledge economy was uncovered, it became clear that most cynicism was directed towards the latter part of this equation; concerning STEM innovation and the knowledge economy. I will turn to this after I have addressed critically the first part of the equation: concerning STEM human capital.

The majority of interviewees welcomed the attention and resources that policy makers had directed towards STEM human capital development. This attention was recognised in terms of the research council studentships which funded three-quarters of the interviewees, and a similar proportion of students at the institution, and investment into the transferable skills agenda. Ambitions to raise the number of young people studying STEM, together with attempts to boost its public image, were also appreciated. However, while the young scientists observed and appreciated these 'input' investments in STEM human capital; a minority articulated an anxiety that the UK's performance of keeping hold of its highly trained human capital was poor. If the 'output' of a globally competitive STEM workforce could not be assured, the human capital investment became a wasted one. Both Rosie and Toru believed that the threat of a UK 'brain drain' was pressing and real. In the presence of these fears, Rosie and Toru found it hard to place great faith in the materialisation of a competitive UK knowledge economy. Rosie saw the decision to raise undergraduate tuition fees from autumn 2012 as making a bad situation worse; it would deter '*bright*' UK students from applying to university, and others may decide to enrol overseas (7). Rosie further criticised the

apparent rush with which the decision to raise undergraduate tuition fees had been taken. She feared that by ‘*putting them up too quickly*’, many UK students would decide not to pursue higher education, because of a general feeling of instability engulfing the sector (7).

Not only did Rosie express concern over the talented UK students who may turn their back on higher education and their opportunity in the knowledge economy; she worried that STEM PhD graduates would look to work internationally upon completion of their degree. Rosie despaired at the lack of opportunities for chemists and engineers, and asserted the UK’s need to provide an infrastructure so that these careers could prosper (7). As Rosie reflected on the possibility that she too may relocate outside the UK in order to fulfil her postdoctoral research ambitions, she berated the wasted investment of a system that did not provide sufficient incentives for highly-trained STEM human capital to stay (10). While Rosie contemplated the idea of looking beyond the UK, Toru’s postdoctoral aspirations were fixed with more certainty. He planned to seek a career in America after his PhD, a vision that he justified with the expectation of greater funding and employment opportunities.

I will probably try and move to the US, where they might appreciate [the PhD] a bit more, unless things in the UK change. [In the US] there are more job opportunities.

(Toru: 7)

While Rosie was keen to ascribe these failings to the government, Toru believed that UK employers must also admit their share of the blame when it came to retaining expert STEM human capital. Toru believed that UK employers were not adequately rewarding STEM PhD graduates in order to convince them to stay. It was thus hardly surprising that in the context of a global market wherein knowledge is desired, individuals like Toru will aim to use their qualification as a form of capital in order to secure favoured work opportunities, wherein interesting job content and good pay are not mutually exclusive choices (11). Combined, Rosie and Toru’s assertions make clear the apprehension that neither the UK government nor industry is acting sufficiently to harness the potential of its domiciled STEM human capital. It is difficult to see how the UK knowledge economy could thrive competitively in the face of such continued reluctance. If Rosie and Toru’s doubts are valid, then their distrust of the knowledge economy narrative is also valid.

5c.5b Innovation

An impression of disquiet also emerged from the interviewee's appraisals of the UK's STEM innovation record. The knowledge economy account of innovation was dismissed by eight of the interviewees for three categories of reasons. The first related to the knowledge economy account of innovation vis-à-vis the *reality* of UK science; the second alluded to a perceived mismatch between the *culture* of academia and the innovation expectations of the knowledge economy narrative; and the third documented a disconnect between the knowledge economy account of innovation and the *personal values* of STEM PhD students.

The first discrepancy that interviewees identified between the knowledge economy vision of innovation and the reality of UK science related to their belief that the linear model of innovation, as presented by the knowledge economy narrative, was incredibly naïve when compared to the reality of science. From their experience, young scientists understood innovation to be a messy, protracted and long-term process. It was not a practice that necessarily held a causal relationship with political pressure or financial investment; it was far from certain that increasing a nation's political or economic focus upon innovation would lead to an increase in innovation. With almost proud defiance of the knowledge economy narrative of innovation, Olivia concluded that there is a *'mismatch between what politicians are paying for and what they're actually getting'* (7).

Drawing from their immediate experience of the PhD, the interviewees shared an account of innovation that privileged serendipity, something that they felt the knowledge economy account did not reflect. The instrumental vision of an aggregate of STEM PhD researchers increasing the likelihood of innovative research simply did not speak to the young scientists as they reflected on their experiences. Despite feeling confident that their research would fulfil the expectations of the PhD requirements, Simon, Isabelle and Rachel were eager to assert that it was not *'groundbreaking'* (Simon: 9; Isabelle: 7; Rachel: 10). At best, these interviewees classified their research as incrementally innovative - as Simon summed up *'I wouldn't say my work is groundbreaking, but it does go against this one guy'* (9). The young scientists did not deplore this situation, for they stood in broad agreement that the most important goal of the PhD was to ensure that the knowledge in answer to their research question was robust. Innovation, as they understood it, related to products and money-making. Even if young scientists thought that one day their research could lead to an innovative product, it was not a relevant concern for the present. As Laurie, who began his PhD thinking that an innovative tool would be a likely outcome explained:

It's become lesser an issue [over time], because getting the knowledge right is so much more important than getting the tool right.

(Laurie: 6)

The second category of reasons underpinning young scientists' hesitation towards the knowledge economy account of innovation concerned the fact that they remained unconvinced that UK academia was optimally configured for encouraging innovation. As I have documented, third-order capitalists Mohammed and Will believed that the culture of UK academia was unwelcoming and consequently unprepared for the university-industry collaborations. Laying the lion's share of criticism at the doors of UK universities, Mohammed and Will accused universities of being too wrapped up in publication cycles - which, coincidentally, they thought had nothing to do with the development of innovative knowledge - and neglecting the building of university-industry relationships (Mohammed: 2; Will: 4). From his experience of working in a company that he claimed sought to foster university collaborations, Will saw no reason to believe this perceived hostility would change. In his opinion, universities were not interested in reaching out to industry, and it would take more than industry alone to make the collaborations happen. As he explained:

There's nothing going on unless [companies] fight for it. There are no academics going to companies, saying, 'I've done this research. You might want to give it a go...'. From what I've seen personally, it's my company that's been doing the chasing. We've been doing all the hard work, so the university doesn't particularly seem to want to get involved, which is quite strange.

(Will: 15, 16)

With this cultural barrier to university-industry collaborations, Will and Mohammed found it impossible to see how the sort of knowledge that Gibbons et al. would refer to as mode 2, could originate. Several interviewees spoke of a lack of R&D funding in the UK, a perception that bedevilled their willingness to accept the knowledge economy narrative, and left them with doubts over how serious UK knowledge economy stakeholders were about boosting the STEM innovation output. Interviewees found evidence for this view from their experiences of job-hunting. They reported a poor number of R&D opportunities in the UK, relative both to what one would expect in a knowledge economy, and when compared to the opportunities elsewhere.

This latter observation caused the third-order capitalists to question whether the UK could be said to have a knowledge economy. Isabelle spoke of the cuts to research funding, and the poor remuneration and prestige associated with her disciplinary profession of engineering (7). Just as Will saw no evidence of the academic culture becoming more receptive to university-industry collaborations, interviewees had little faith that financial investment into R&D infrastructure would be boosted in a time of austere public spending. Mohammed agreed, stating that at present cost-efficiency, rather than innovative solutions, took priority in agendas of research-intensive UK firms (15). In Mohammed's view, overlooking the need to improve the UK's R&D infrastructure meant that the government would not '*yield the results [they] want*' from publicly funded PhD studentships (13).

The third and final basis for rejecting the knowledge economy account of UK innovation concerned the personal values of STEM PhD students. It was widely believed by interviewees that young scientists were simply not interested in proactive involvement in technological innovation. As Olivia reflected, '*I don't know anyone whose interest is in... patents*' (7). Personal lack of interest in innovation could feasibly relate to the first category of reasons for rejecting the knowledge economy account of innovation; as if to say the view that innovation was not part of the PhD experience. This in turn would provide evidence of scientific values being shaped by practice. Of greater concern however, was that young scientists demonstrated little confidence that they would be part of innovative and entrepreneurial activities later in their career. Rather than developing a mindset that encouraged thinking about their research in terms of potential applications and patents, interviewees generally maintained a collectivist view of science, with little concern about individual ownership. As Laurie explained:

My aim was to bash out this tool that people could pick up and use. Now I don't care when that happens so much. Obviously the sooner the better but it doesn't have to be part of my PhD. It doesn't have to be me that does it.

(Laurie: 6)

Of course, the third-order capitalists would be likely to disagree with this attitude; nonetheless, it remained predominant across the other interviewees. Through reflection upon their own motivations, and that of their peers, it is easy to see why many interviewees remained unconvinced

by the archetype of the scientist-entrepreneur in the knowledge economy. They certainly did not see it as their likely rite of passage. If the focus of young scientists remains fixed upon knowledge production only, and they continue to care little about the ownership of their research to the stage of commercialisation, then the knowledge economy aspiration of the scientist-entrepreneur seems unfounded. This situation would present a fundamental flaw in government and industry thinking, and one which - being a matter of personal values - would be complex to address.

5c.5c Between rhetoric and reality

A final incidence of skepticism arising from the interviews concerned the perceived gap between the rhetoric - of policy makers and industry - and reality. This of course ties to the particular criticisms regarding human capital and innovation as discussed above. However, the point here is that interviewees were not simply criticising the naïvety or incompetence of politicians and industry stakeholders; rather, this strand of criticism denotes distrust, most commonly towards politicians. Graham was perhaps the most ardent proponent of this perspective, believing that politicians spoke of the knowledge economy in order to amass political capital; it signified a vision of growth, and the promise of a better future for UK Plc, and it implicitly suggested that politicians were in some way in control of, or responsible for, this development. This, Graham held, was a complete fabrication. Consequently, Graham suspected that references to the knowledge economy were little more than *'blah, blah, blah, blah, politics sound bite, little substance'* (6).

Weak pragmatist Jack worried that in the contemporary climate of restrained public spending, the narrative of the knowledge economy was being used for politically expedient purposes (2). Since he understood it to imply a shift from the public funding of research to the greater involvement of industry, he saw the knowledge economy as presenting a convenient framework upon which cost-cutting decisions could be hung and granted a deeper rationale. While Jack recognised the benefits of having some industrial involvement in the university, he believed that this funding model was not a sustainable way to assure the future of basic research (3). Jack expressed further annoyance at politicians' talk of a knowledge economy because, as far as he could see, STEM PhD graduates faced a shortage of appropriate 'knowledge economy' jobs - a belief upon which Isabelle and Mohammed also agreed (Isabelle: 10; Mohammed: 14). In similar terms, Dylan concluded that the lack of R&D investment and appropriate jobs for STEM PhD holders meant that the UK could not yet be said to have a knowledge economy, and for this reason, he was cautious to make a definitive judgement as to whether it would be a positive or negative development for UK science (2).

5c.5d Addressing these limitations

While many of the criticisms raised by young scientists toward the knowledge economy seem legitimate, the lack of consensus over who is to blame, and what needs to be done, is notable. Knowledge economy stakeholders may wish to act to allay the concerns of young scientists, but how they do so is not clear cut. Finding an answer is unlikely to be easy; after all, the dissensus of the young scientists reflects the unique moral positions towards the knowledge economy and the associated normative views on science. While the interviewees may agree that more university-industry collaborations need to ensue before a UK knowledge economy can be properly spoken of, the weak pragmatists and the third-order capitalists would, for example, disagree over the extent to which the university as an institution, and the PhD as a training model, should adapt in order to facilitate these collaborations. Visions of an ideal infrastructure for the UK knowledge economy will differ, because the image of the ideal knowledge economy is so varied. Addressing young scientists' criticisms of the knowledge economy is likely to be a fraught process; not least because of the moral convictions it will encounter.

5c.6 Conclusion

This three part chapter has confirmed that the knowledge economy is a known phenomenon to young scientists, and it has detailed the five moral positions that the young scientists formed in response to it. Young scientists' views on the limitations of the knowledge economy were also identified.

In this detailed account of the five moral positions, I have made clear some of the links of the hermeneutic circle. We have seen how normative statements on science, the epistemic cultures of distinct disciplines, and past research and work experience combine to produce a scientific identity that encapsulates a fixed moral position on the knowledge economy. Thus, in examining the five moral positions on the knowledge economy, we have, at the same time, come to understand five types of scientific identity possessed by the young scientists. A further important point to note is the need for consistency between these influencing factors. In other words, if one's identity is that of a scientific purist, then the decision to adopt a positive attitude to the knowledge economy would mean moving along to spectrum to the position of weak pragmatism at the least. In a similar way, the third-order capitalists' openness to the knowledge economy reinforces, and is reinforced by: their motivations for studying a STEM PhD; their hopes for a career in science; the epistemic norms

of their applied disciplines; and their past experiences of work and research. It is the logical appraisal of all these complementary factors that leads them to their distinctive moral attitude to the knowledge economy, and the more general sense of their scientific identity. In the next chapter (6), I turn to look at how these five scientific identity types, and their correspondent moral positions towards the knowledge economy, shape the behaviour of young scientists in their daily lives as doctoral researchers.

6. 'Science in action': young scientists and identity construction

6.1 Introduction

In this chapter, I explore how young scientists construct their identity during the STEM PhD. We shall look at the decisions that young scientists make with regard to research topics, publications, networking and careers planning. Using Donald Stokes 'Pasteur's quadrant' model (1997), we will see how the five moral positions lead young scientists to form very different views on the nature and purpose of scientific knowledge. I reveal how the decisions and behaviour of young scientists are geared towards identity construction; and that - as we saw in chapter five - the type of identity that a young scientist aspires to is underpinned by normative views on science and the knowledge economy. What we see in this chapter therefore is how young scientists' moral positions on the knowledge economy inform their scientific identity construction and, more tangibly, 'science in action' - so to say; research behaviour, professional networking and career planning.

Throughout the chapter I will argue that the STEM PhD is a highly individual experience; just as young scientists' understandings of what constitutes a desirable scientific identity are non-uniform. Indeed, the very presence of the five moral positions undermines the Mertonian notion of the impersonal scientist as committed to, and defined, by universal norms. In Kuhnian terms, we can say that for the contemporary young scientist, there is not one overarching normal paradigm as far as the knowledge economy is concerned. The five moral positions represent an ambivalence amidst young scientists as they figure out the normative implications of the knowledge economy for science and their scientific identity. Young scientists recognise that the Mertonian norm of disinterestedness is deficient for the age of the knowledge economy; however, they have not yet found a single replacement model of identity to respond to the demands of this time. Rather, we have five compelling articulations of scientific identity, and in this chapter we see how influential the moral positions and associated beliefs about science are in guiding young scientists' decision-making and behaviour.

Throughout this chapter, we will see how imagining a future vocational self reinforces the particular scientific identity of the present; so to say, the self that young scientists think they will become keeps them bounded to their current moral position. The lack of an overarching normative paradigm regarding science in the time of the knowledge economy has not inspired apathy in young scientists;

rather, they are shown to be proactive, interested individuals who are outspoken proponents of their chosen scientific identity.

Scientific identity construction is a complex and nuanced process. The majority of young scientists in this study began their STEM PhD with the primary ambition of becoming an academic. Opening their minds to other career trajectories and imagined vocational selves can be hugely challenging, as the weak and strong pragmatists especially testify. Furthermore, young scientists are shown to have a preoccupation with the coherence of their scientific identity: moral positions, experiences of science, and future plans cannot be radically at odds with one another. The need for a coherent normative logic, together with an apparent aversion to cognitive dissonance, limits the range of scientific activity and careers that young scientists consider, precisely because they do not want to undermine their expressed identity. In the next chapter (7), I consider this constraining effect in more detail, arguing that a *'liquid'* conception of scientific identity would serve young scientists better in the knowledge economy.

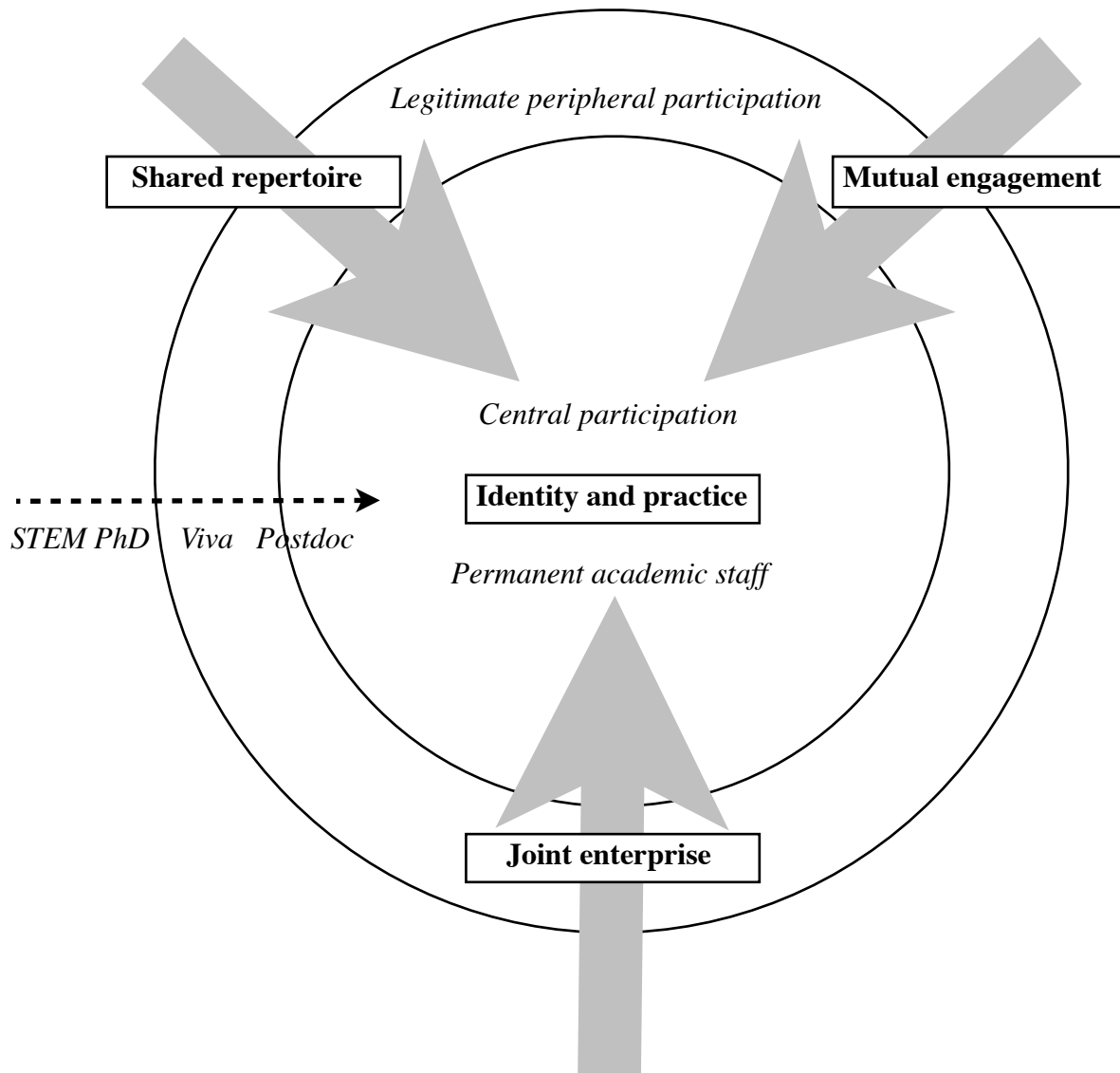
The analytical approach of this chapter is informed by game theory. I will argue that through the course of the STEM PhD, young scientists' are involved in a game, played in reference to scientific identity construction and desired career outcomes. These game strategies are pervasive; informing young scientists' attitudes to the immediate context of the university; publications; risk; freedom; knowledge; public engagement; and, careers. Particular game strategies correlate to a distinct scientific identity, and they instruct young scientists to respond strategically to the uncertainty of their PhD experience in order to forge a career that is at peace with their scientific identity.

6.2 The theoretical framework: rejecting Communities of Practice; embracing game theory

Before discussing the particular game strategies of young scientists, I will justify my choice of a game theory informed approach.

For researchers investigating the socialisation of new incumbents into a community of experts, the most celebrated theory of the past decade has been Etienne Wenger's *Communities of Practice* (COP) model, first published in 1998. In Wenger's theory, learning is a social process and it therefore follows that the anticipated trajectory for a STEM PhD student would be from the margins of the community of experts to somewhere well within its *'legitimate peripheral'* borders of

participation as they approach the viva.³⁰ Passing the viva and obtaining a postdoc position would ensure their further travel from the periphery to the center of the community of practice. By the time they achieve a permanent position as a university lecturer or researcher, they would be nearing the centre-point of the sphere of 'central participation'. This hypothesised trajectory is illustrated in figure 6.1 below.



Adapted from Wenger (2007)

Figure 6.1 The academic community of practice

COP suggests that as the early-career scientist travels from the periphery towards the community centre, an identity shift follows. It is not necessarily the case that arrival at the central participation

³⁰ The known experts of a specific field would be placed at the centre of the community.

sphere represents the conclusive state of one's identity (Wenger, 2007:152). Wenger argues that professional identity rests upon a mutually recognised level of competence from other established members of the community. The community is thus premised upon mutual engagement, joint enterprise and a shared repertoire (Ibid.). The individual who exists in the sphere of central participation ought to have an awareness of, and thus gain confidence from, their peer-reviewed competence; but this does not mean that complacency can ensue. The COP is a community of continual learning, and so the implication is that professional identity is in a state of '*constant becoming*' (Wenger: 154). For this reason the successful completion of a doctoral thesis would not define an individual's relationship with the COP; rather, this relationship would continue to develop throughout their professional life. The modern understanding of the PhD as the apprenticeship for an academic career fits well with the COP model. Figure 6.1 shows how the STEM PhD researcher might be expected to move from the periphery to the centre as they progress on their career path. Identity would shift with successive academic promotions, but membership of the COP is constant.

There are two principal reasons why I do not believe that the COP model generates a realistic portrait of the socialisation of contemporary young scientists into science. The first reason to reject COP is that for those contemporary young scientists who do enter the university COP, the model is oversimplified. Early-career scientists within the university COP will experience uncertainty beyond their first postdoc; and so the implication of a linear and upwards career ladder in which one's confidence and security increases with expertise is misleading. For those young scientists who do achieve a first postdoc, their progression to tenure is neither guaranteed or straightforward; current Vitae statistics demonstrate that not only are academic jobs distributed in the shape of a permanent and steep pyramid - with far more early-career positions at the base and far less senior positions higher up; but also that many of those postdocs who leave the university COP may one day return (Vitae, 2011). In addition, for those who stay within the university COP, greater movement across different areas of expertise is being observed; meaning that beginning one's career in a university research role does not preclude the possibility of a horizontal switch into, for example, a different field of scientific research, professional development, careers guidance or administrative or managerial roles. Furthermore, in chapter seven, I fully expound my reasons for arguing why even those young scientists who remain in the university COP will increasingly be required to work collaboratively with other COPs; such is the expectation for the scientific researcher in the knowledge economy. In the knowledge economy, university academics enter a new contract with the economy and society, wherein the monetary impact of their research is of

foremost concern. Thus, alongside teaching responsibilities, the context of research has changed, necessitating greater interaction with non-university partners – which may mean that sizeable amounts of time are spent outside the university COP in other sites of scientific research; and also, more time is focused upon evidence-based policy and public engagement. Wenger does acknowledge the presence of ‘*constellations*’ of communities of practice, across which individual members and interests may be shared (Wenger: 127). Nonetheless, the constellation model is not evocative of the ivory tower of the modern university; an image that, worryingly, the scientific purists, socially-oriented young scientists and third-order capitalists continue to invest in. For these reasons, I conclude that COP does not sufficiently encapsulate the complexities of the working lives of contemporary university-based scientists.

The second reason to reject the COP model concerns those young scientists who do not stay in the university upon completion of their thesis. COP is not a useful means of theorising about the trajectories of young scientists who will forge a career outside university science, which may be problematic for university staff involved in supporting the career-planning and professional development of these early-career researchers. These young scientists need to be flexible; focusing instead on the transferability of their skills in order to maximise the variety of COPs in which they may be able to forge a participatory role. The emphasis upon transferable expertise and skills is of course a central tenet of knowledge economy policy; and the success of the young scientist in seeking appropriate knowledge work in alternative COPs to academia will determine their return from the STEM PhD investment; so to say, whether the policy promise of creative, interesting and well paid knowledge work is realised. For these young scientists, the boundary-mentality of COP is likely to be unhelpful. Moreover, COP thinking may give young scientists the impression that they ought to stay within the university community they have entered, and that leaving denotes a great professional risk. Reflecting on the pyramid of jobs evident in the Vitae statistics, this is clearly not so. The reality is that most young scientists will leave the university COP after their doctorate or successive postdoctoral positions. COP does not adequately capture the frenetic and non-linear nature that their professional path across other scientific, multidisciplinary or even non-academic spaces of work is likely to feature.

The fundamental problem however with COP as a model for shedding light upon the STEM PhD experience lies its intense focus upon the community with the consequent neglect of the individual. The data accrued in this study contrarily presents the STEM PhD journey as a unique, individual

experience; a story that cannot be comprehensively told through the analysis of a community or social networks. It will be evident throughout this chapter that many young scientists feel isolated throughout their PhD experience; in constructing their present scientific identity, and when looking to the future. For young scientists, there is no single obvious COP for them to join. Their career may involve a COP quite distinct from that of university science, wherein they once stood at the periphery, or it may involve a looser association with several COPs. Intermittent episodes of group-work, or sporadic networking with other researchers at a conference - the types of social professional interactions that punctuate young scientists' doctoral experiences - do not fulfil the definitions of social learning, mutual engagement and a shared repertoire expected by the COP model. The lack of community – in both present and future – leads young scientists to conclude that they are on their own; and in consequence, they develop highly strategic responses in order to manage their personal preferences.

I suggest that a game theory informed analysis of the data offers a more appropriate way to theorise about the decisions made and values held by contemporary young scientists. There are three main reasons why I advance this proposition. The first is that game theory emphasises the *individual* nature of each young scientist's doctoral journey, dispelling the myth that young scientists perceive their PhD as the moment at which they enter a stable COP. The second strength of the game theory analysis is that it draws out the *competitive* environment that young scientists inhabit, and exposes the highly strategic thought-processes and decisions that this context provokes. The young scientists of this study prove to be highly ambitious; each individual has a clear vision of the professional outcomes that they desire - in accord with their scientific identity - and they are aware that they are competing with peers, internationally, in their bid for success. The continual sense of competition - arguably not new to science, but most certainly intensified with the pace of today's globalised world, and felt more readily by young scientists at the bottom of the career ladder - has the effect of intensifying feelings of individualism. The third and final major strength of game theory is that it allows us to examine in detail the strategic thought and *decision-making processes* that lead young scientists to a particular scientific identity, a particular normative view of science, and a particular set of career aspirations. It will become clear that decisions are based upon values but also calculations of *risk* and *probability*, which game theory enables us to examine. We will see that across the moral spectrum, young scientists vary in terms of how they compose their calculations and form an eventual decision; what all young scientists do share however is a belief that their strategy is best, and - linking back to the emphasis on individualism - there is a conviction that if

the right decisions are substantiated by hard-work, just deserts will be delivered. This sense of entitlement - strongly reminiscent of the Thatcherite individual - is common to all young scientists; notably, young scientists do not readily admit plans for contingency in response to failed strategies or bad fortune.

Simply put, game theory analyses the strategic decisions and behaviours that an individual pursues in order to heighten the chance of bringing a desired outcome to fruition. Originally located in mathematics, and developed primarily through the pioneering work of John von Neumann (1903-1957) and later John Nash (1928-present), game theory has been applied to disciplines outside mathematics; namely, economics, evolutionary biology and political science (Binmore, 2007: 3). This endeavour of applying a game-theory informed analysis to a social study of science appears to be novel. Game theory can be used to *prescribe* and *describe* the decisions and actions an individual may enact in order to achieve their preferred outcome.

The application of game theory in this analysis is specific and consistent; however it is admittedly constricted in scope. Crucially, I am interested in game theory as a descriptive device. I do not make predictive statements about young scientists, since their narratives reveal their propensity for change. As I have already stated, the majority of young scientists began their PhD with the intention of becoming an academic, and for all but the scientific purists and the socially-oriented young scientists, this ambition changed over time. This change in ambition is followed by a strategy of behaviour and career planning in order to assure the successful construction of a newly defined scientific identity. In contrast, for those young scientists who maintain their pledge of becoming a university academic, we see that this commitment becomes stronger over time, and the PhD is pursued solely with this career objective in mind. Thus the value of a game theory informed analysis is that it responds to the assertions of rational self-interest articulated by young scientists, and provides an explanation for their reported behaviour. Game theory exposes the PhD as a time of calculated risk-tasking, geared towards the construction of a prosperous and coherent scientific identity.

The rest of the chapter discusses the five game strategies that relate to each particular scientific identity. Before we begin, I must acknowledge the 2006 work of Lisa Lucas, *The Research Game in Academic Life* (2006) since it somewhat mediates the originality of thinking about the 'games' involved in academic life. In this work however, Lucas' reference to 'games' is largely

metaphorical. Drawing not from game theory proper, Lucas evokes George Orwell's dystopian novel *1984*, and looks at the structuralisation of academic life in 1990s UK universities. Lucas' game is centered around the rules of research funding, and how '*the intoxication of power and the thrill of victory*' are perhaps more meaningful prizes for academics than peer-acknowledgement of research quality or securing a sum of funding to satisfy research aims (Lucas, 2006: 2).³¹ While I do not wish to detract from the importance and creativity of Lucas' analysis, I believe that Lucas' reference to the game of academic life is different to my own in two ways. Firstly, Lucas focuses upon the structural and organisational level and does not look at individual decision-making strategies to the extent of the depth that I offer here. Secondly, I believe that Lucas' reference to the game is purely metaphorical; within the book, there are no explicit references to the concepts of mathematical game theory of the sort that I will use. The metaphor of the game of scientific life creates a powerful image that this analysis is indebted to; nevertheless, the individual strategies of young scientists are examined here with more precision than a metaphorical comparison.

6.3 A future in science: the games played by young scientists

In this section I will examine the particular game strategies employed by each scientific identity type across the young scientists.

6.3a Scientific purist

The scientific purists, being anti-knowledge economy, imagined their future vocational self to be working within university science. Given the continuity of this image with their present doctoral student self, it is plausible to think that the scientific purists might be one of the least strategic groups of young scientists. They remain committed to their original vocational ambition, and had not undergone the upheaval in career planning and identity construction claimed by other interviewees. The game strategy of the scientific purists involved a commitment to finishing the doctorate, respecting the norms of scientific life in the university and securing a postdoc.

The scientific purists' moral rejection of the knowledge economy is a significant characteristic of their game strategy. There is a sense in which their moral position is strategic: the scientific purists appear to believe that a commitment to only one desired outcome - an academic job - would pay off in the long-run. The rationale for this is clear to see; success in a notoriously competitive job market

³¹ Satisfice - the combination of satisfy and suffice - refers to a decision-making strategy that aims to acquire enough to satisfy and suffice for one's needs. This is contrasted with, for an example, a maximising strategy that aims to acquire the best possible outcome, even if one's needs could be met with a lesser outcome.

demands dedication and perseverance. This is not to undermine the moral problem that the knowledge economy causes for the scientific purists' normative view of science. Nevertheless, it is important to note that what may first appear to be a straightforward moral position neatly complements a careerist mindset.

For Sophia and Marigold, securing a career in academia - or at the least certainly *not* in the private sector - is the subject of a 'zero-sum', all or nothing game. Although few things in life truly are a zero-sum game (Binmore, 2007: 10); Sophia and Marigold thought that the total sum of their future career happiness rested upon a career outside the knowledge economy. The distinction they make is absolute.

I want a career in research... I don't want to work for a private corporation. I feel this is why I've done the PhD.

(Sophia: 6)

I'd like to be in research, so yes I'd like to do a post doc. It's remained throughout. I don't think so much has changed through the PhD.

(Marigold: 6)

Alice displayed what is known as a combinatorial game strategy, in which more than one outcome – or in this case, career option - is deemed desirable, thus making an optimal strategy harder to select. Although Alice was expressly anti-knowledge economy and dismissed the notion of a career in industry or a for-profit corporation, she stretched her imagination to working in government or for a charity, should academia not work out.

I've sort of got a couple of vague plans, one would be maybe to do a post doc, if I can find the funding and it's an interesting project that is worthwhile doing. On the other hand I'm not sure I want a career in science, because all the post docs I see now are just really scrambling around for funding and they are living from month to month and I don't think I want to be that insecure in terms of knowing where my next pay cheque is coming from... The other area I probably want to go to is more policy driven. I did a

little bit of that before starting the PhD, working in a government quango and I really enjoyed that.

(Alice: 12-13)

Alice's multiplicity of choices give rise to a sense of anxiety, and it is evident that this fed back into her PhD; she recounted feeling at times torn over whether to direct her PhD work towards the interests of her university supervisor, or the wishes of her charity sponsor (6). It is interesting that in Alice's thoughts, observations of others on a similar trajectory to the one she envisages for herself are influential. She does not want to be '*scrambling around for funding and living from month to month*' (11), as she perceives many postdocs to be. Devising an optimal strategy in any game depends upon the appropriation of and reflection upon competitors' behaviour. If Alice can see that the working conditions for a university postdoc are likely to be financially and psychologically tough, then she is likely to think twice about the costs involved and the odds of success. On balance, she seems to think that she may have an advantage by moving into something that she has prior experience in, such as a '*more policy driven*' role (12). To strengthen the possibility of her securing this work, Alice revealed that she took the time to keep up to date with relevant policy (10). Multi-tasking is indicative of a combinatorial game strategy.

The information set of game players is crucial to the development of an optimal strategy, and by observing the fates of other postdocs, Alice arguably triumphs over Sophia and Marigold in producing a more robust strategy. Sophia and Marigold's intransigence no doubt indicates how important an academic career is to them; but it is a high-risk, non-rational strategy all the same. Marigold and Sophia appear to ignore career statistics like those earlier quoted from *Vitae*, allowing their scientific values, rather than pragmatism, to govern their career planning. There is of course the additional possibility that Marigold and Sophia operate on imperfect information sets; so to say, they are unaware of career statistics, or the picture generated by *Science is Vital* regarding the poor state of UK science careers. If this is so, it is possible that Marigold and Sophia believe that they are acting rationally and in a low-risk manner; but that they are simply thwarted by ignorance. If Marigold and Sophia believe that they have already broke through to the tier of legitimate peripheral participation in the university COP, then it would be rational to build upon this foundation, rather than to divert efforts into other potential careers. This strategy would echo the advice of John Rawls, the twentieth century philosopher, concerned primarily with moral theories of distribution. In his seminal work, *A Theory of Justice*, one of the points made by Rawls is that in most scenarios, it is rational to be *risk-averse*. This means that individuals should invest their efforts

into protecting what they have rather than chasing as yet un-acquired assets (Rawls, 1972). If Marigold and Sophia naïvely believe their STEM PhD represents the first step in the path to a guaranteed academic career, then they are being rational by putting all efforts into this trajectory alone.

However, it seems unlikely that the scientific purists could be fully ignorant of the realities of contemporary UK science careers. They would observe the difference between the number of PhD students, postdocs and tenured academics on a daily basis in their science-intensive institution. The notion that Marigold's and Sophia's strategies are a Rawlsian act of defence lacks persuasiveness. Thus, we are led to the interpretation that Marigold and Sophia do operate on a perfect information set but that they chose not to entertain the possibility of a 'knowledge economy' job. Simply put, values are consciously placed before pragmatism. Sophia's admission that she could not '*fathom*' (6) how other STEM PhD graduates work in the private sector supports the idea of a conscious decision. Nevertheless, one area where the scientific purists do appear to rely upon an imperfect information set is with regard to their understanding of an academic career. By placing it at odds with the knowledge economy, Sophia and Marigold imply that an academic career is relatively sheltered from it. This perception finds traction in Marigold and Sophia's source of funding; both are supported by the UK Research Council and they view these funding bodies as 'pure' insofar as they are not private capital. That the Research Councils are conduits for the allocation of government money, which arrives with politically-imposed conditions attached, is a point missed by Marigold and Sophia. Knowledge economy policies have transformed the role of the academic, as the survey data cited in the previous chapter testified. There is a real chance that the expectations of the scientific purists will not transpire into reality, though they seem unprepared for this. In sum, we can say that the scientific purists plan their strategies with a bounded rationality; their propensity to make rational decisions is limited by both information set and *a priori* moral values.

Sophia, Alice and Marigold implied that the STEM PhD was an academic apprenticeship, at the threshold of academia proper. Sophia and Alice suggested that the ultimate task of the PhD student was to produce knowledge that would be publishable in a peer-reviewed journal, thereby demonstrating their intellectual worth. They explained:

The main thing is publications, so you want research that can get published... I do research in a university, and I carry out my own little bit of research, I write it up and then I publish, to show that I'm worthy of having a career in research.

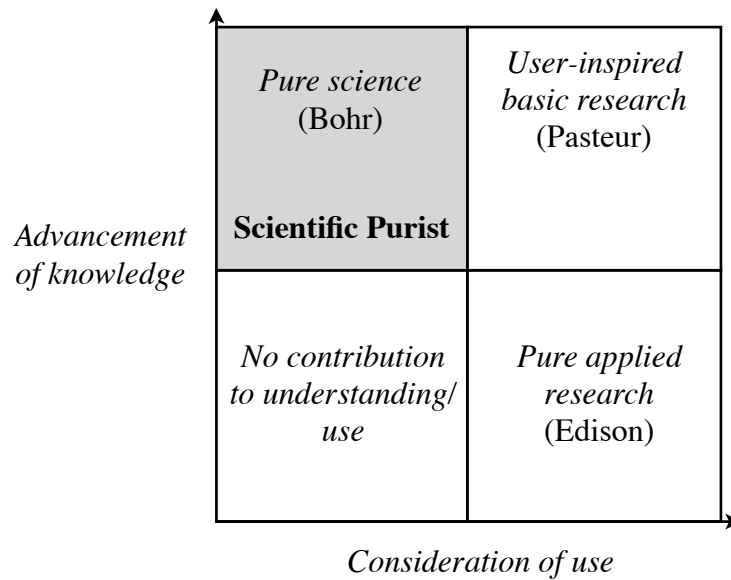
(Sophia: 3; 6)

[As a PhD student] you are being paid to do research, so at the end of the day you are expected to produce publishable good scientific work. You are being trained in a particular subject; you are being trained as a scientist.

(Alice: 8)

Tailoring one's PhD research to ensure publication is an important element in the strategies of the scientific purists; something that cannot be said for all young scientists, as we will see in due course. The scientific purists are beginning to mirror the behaviour of professional scientists. For the scientists observed in Latour and Woolgar's *Laboratory Life*, the production of scientific papers is the *raison d'être* of professional life (Latour and Woolgar, [1979] 1986). The scientific purists were interested in innovation insofar as it referred to the intellectual innovation necessary for publishing. A knowledge economy understanding of innovation did not correspond to their aspirations (Sophia: 8; Alice: 11). Marigold concurred with this sentiment. She explained: '[PhD students] *come out with new ideas*' (6), which other interested agents may then commercialise. The scientific purists do not concern themselves with thoughts of utility or profit-potential. They viewed the day to day life of the scientist as consumed with incremental improvements consistent with periods of normal science (Sophia: 9; Marigold: 6; Alice: 11).

Donald Stokes' 'Pasteur's quadrant' (1997) offers a way of thinking about scientific knowledge that goes beyond the basic/applied dichotomy. Stokes argues that there are four important distinctions to make with regard to academic research. Three of these are concerned specifically with problem-solving. The origin of a problem differs in each scenario: it may be a fundamental concern in basic science; it may be aimed at solving a problem of application; or, it may have the need of a user in mind. Pasteur's quadrant is thus a more accurate way to think about the different types of scientific knowledge and the discrepancies which set them apart. I will refer to it throughout this chapter, as I indicate which type of scientific knowledge is prioritised within the diverse strategies of the young scientists. For the scientific purists, their allegiance to knowledge is located within the top left square of the quadrant, shown in figure 6.2 below.



Adapted from Stokes (1997)

Figure 6.2 The scientific purists and Pasteur’s quadrant

This top-left square represents a commitment to ‘pure’ or basic science, and Stokes offers the Danish physicist Niels Bohr as an ‘ideal type’ in order to represent this mentality. Bohr was an atomic and quantum physicist who won the Nobel Prize in 1975 for his fundamental contributions to physics and chemistry. This is not to say that Bohr was anti-application; he was one of the architects of CERN. However, his fundamental concern was with the minutiae of scientific knowledge; and with perfecting this before thoughts of applications could be addressed. Sophia, Marigold and Alice are similarly wrapped up with honing the knowledge that will provide the best answer to their research question rather than looking ahead to possible applications.

A further part of their strategy to embark upon a successful academic career is revealed in the scientific purists’ attitudes to academic freedom. Upholding the traditional image of the STEM PhD as the training period of the university science, the scientific purists balanced a cautious and yet welcoming attitude to freedom in their PhD. On the one hand, the freedom of science from private interests is necessary to their scientific ideals (Marigold: 8; Alice: 6); and thriving within academic freedom allowed one to visibly demonstrate aptitude for science and prove an appropriate skills-set (Sophia: 5). On the other hand, Marigold, Alice and Sophia agreed on the need for support and guidance during the PhD. Expressing this tension, Alice stated:

You do need someone to kind of remind you that you haven't got endless time to do this, but at the same time you need the freedom to allow the fact that when you start the research, every single person I know who has done a PhD... [has] needed to change it. You need to have that freedom to recognise flexibility in your research.

(Alice: 6)

The scientific purists were keen to assert the value of the apprenticeship model and of demonstrably following their supervisor's advice in order to secure their safe-passage through the PhD, and also, to win their supervisor's approval.

I have had a lot of advice from my supervisors. I get a lot of ideas from them.

(Marigold: 5)

The significance of the supervisor relationship is an example of a strategy of *cooperation* used in the scientific purists' game strategy (Binmore: 140). To enhance the prospects of an academic career, the scientific purists sought a good relationship with their supervisor. This relationship was deemed central to the acquisition of expertise and positive career references. Sophia's belief in the importance of having a good relationship with one's supervisor arose from her experience of the contrary.

I hadn't expected the lack of supervision that I've had, the lack of support. That's been a real problem and I don't know if that relates to my individual supervisor or the wider environment of [the university].

(Sophia: 5)

Interestingly, Sophia lay most of the blame for her poor relationship with her supervisor upon the 'corporate' behaviour of the university and its pursuit of profit at the expense of standards (12). Thus, her negative experience reinforced her belief in the importance of the university as providing sanctity for traditional and 'pure' academic research.

An additional strategy employed by Marigold was an expressed commitment to teaching. Alice and Sophia did not mention any involvement in teaching, and it is not a requirement of this university that a PhD student must undertake any. However, in order to increase her chances of academic

success, Marigold revealed that she actively sought teaching responsibilities; complementing both her professional self-interest and her Humboldtian understanding of the university (6).

6.3b Socially-oriented

It was the moral view of the socially-oriented young scientists that academic science should be linked to a knowledge *society*, at the heart of which is the agenda of enhanced social justice. Since Olivia and Rachel believe in the existence of a social contract between scientists and society, thoughts of individual self-interest appear to be lessened. Thus at first glance it may seem as though a game theory analysis, which is centered upon the realisation of self-interest, is unfitting. However, I would counter this by arguing that it is in the self-interest of the socially-oriented young scientists to act in ways deemed compatible with their knowledge society view. It is their expressed wish to seek altruistic knowledge society work, and they employ the same type of strategic reasoning as other young scientists across the moral spectrum in order to meet their personal preferences. Altruistic, knowledge society science can still be thought of as a ‘reward’ as far as the career planning of the socially-oriented young scientists is concerned.

Rachel and Olivia both believed that seeking a postdoc after their PhD formed their most likely career strategy (Rachel: 11; Olivia: 10). However, they were more open to the adoption of an outward facing identity as an academic than the scientific purists; most likely as a result of their disciplines which – being medical research and conservation - are grounded in real world issues. Thus Rachel and Olivia conceived of their future selves as academics for which public engagement and social impact comprised important elements of their scientific identity and work (Rachel: 3; Olivia: 3). Since Rachel and Olivia saw themselves as staying within academia, they gave priority to similar areas of the PhD as the scientific purists. Publications were a primary focus for both. Rachel believed that the importance of the PhD population was summed up by the publications it contributed to science (8); and somewhat conversely, Olivia despaired that her inability to publish any of the results of her PhD – something she had taken for granted as likely to happen – might damage her employability within academia (4). For the same reasons outlined in our discussion of the scientific purists, it is ambiguous whether the socially-oriented young scientists thought they were pursuing a high-risk strategy - focusing solely on securing one of the limited number of academic jobs; or a low-risk strategy - consolidating the professional path that they were already on.

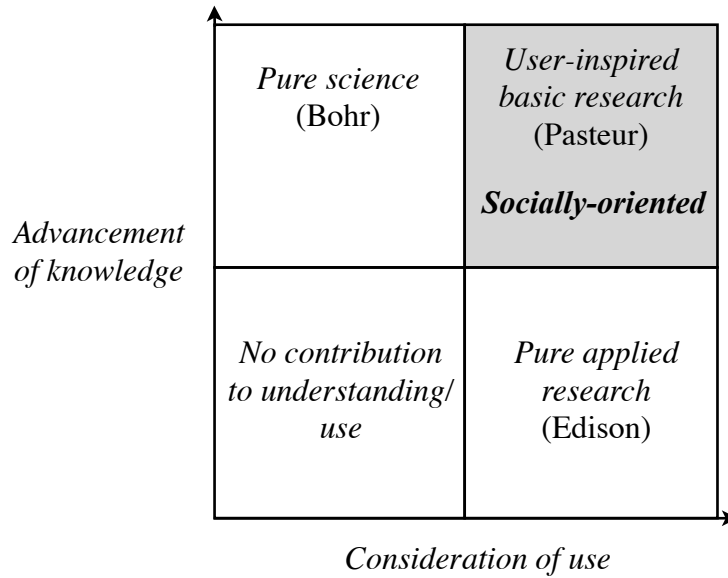
Not only did the socially-oriented young scientists emphasise the societal impact of science, they highlighted also the importance of the social *within* science. One of the main aspects that excited Rachel about a knowledge society was the thought that her knowledge could be shared with others (12-13). In light of her disappointment over publications, Olivia consoled herself by pointing out that she would be able to share tacit knowledge with other researchers in the next lab that she worked in (4). Both Rachel and Olivia expressed the importance of finding support and inspiration within one's close-knit scientific community in order to become a good scientist. Olivia had many complaints about her primary supervisor, but found a saviour in one of the collaborators on her project.

There is a collaborator from the Netherlands who comes over occasionally and he's a really great guy. So, I've been influenced quite a lot by him and his publications and just thinking what would he do... I don't really pay any attention to [my supervisor].

(Olivia: 8)

Olivia admitted that when she felt overwhelmed with frustration over her PhD, or doubts concerning her future as an academic, the project collaborator boosted her confidence and helped her to refocus. She thus made the extra effort to maintain a friendly correspondence with this academic. Rachel similarly admitted that the attitude of her supervisor had been vital for her continued confidence in her scientific ability, and in tailoring her PhD to build upon her interests and strengths (3). It is clear why both Olivia and Rachel would come to view science as a social activity, and one in which supportive personal relationships are integral to the flourishing of the individual. For the socially-oriented young scientists, science is a collective enterprise through and through.

Rachel and Olivia envisaged a scientific career responsive to the societal implications of science. This is evident in terms of the types of scientific knowledge each were set on developing. For Olivia, this meant medical knowledge, since she specialised in cancer research (3). Rachel desired a career in conservation research, and admitted that she felt '*lucky*' to be located within a research area associated with obvious social value (3). In terms of Pasteur's quadrant, the socially-oriented young scientists are placed within the upper-right square (figure 6.3). For the socially-oriented, there is no tension created between basic scientific knowledge and knowledge which fosters a socially useful outcome; indeed, this is the only type of science they are willing to recognise.



Adapted from Stokes (1997)

Figure 6.3 The socially-oriented and Pasteur’s quadrant

While the output of pure applied research and user-inspired basic research may often turn out to not be all that different, the fundamental ethos underpinning each is. As such, it has already been documented that Olivia and Rachel cannot imagine themselves being motivated by profit, and would not identify with Edison’s approach to science. In fact, they actively renounce such an approach to science. I may refer to the ‘self-interest’ that guides them towards altruistic academic research, but they would most likely reject the label of being ‘self-interested’. Olivia judged the knowledge economy and UK universities as being intent on profit-making, and she viewed this motive with scorn (1; 12). Rachel concurred that this framework harbored no appeal for her, for she was simply not motivated by money (3). Both Olivia and Rachel remained focused on staying within their discipline, and so the transferability of their skills to the pure applied square of Pasteur’s quadrant was not a strategy they envisaged pursuing.

It is interesting that, such was the commitment of the socially-oriented young scientists to a more egalitarian vision of science and society, the language of the knowledge economy mattered to them. More precisely, it offended them. Olivia dismissed innovation as being something that did not concern her as a STEM PhD student, because it had become a ‘*money-making*’ word (9), whereas Rachel failed to see how ‘economy’ could be an appropriate way to describe the vision of science

that she had in mind. When we look at the policy narrative of the knowledge economy, we see that words such as entrepreneurship and innovation have been narrowed and re-branded for ideological purposes. For STEM PhD students who feel as though the knowledge economy presents a desirable space for them, such linguistic effects are likely to be unproblematic. However, for the socially-oriented and the scientific purists, who see themselves as anti-knowledge economy, there is a danger of encouraging a polarisation in views on science, by casting certain words as ‘belonging’ to the knowledge economy. The language of the knowledge economy is therefore an important device in influencing the support it might receive from young scientists. Stakeholders of the knowledge economy who wish to convert the unconverted to their cause, ought to realise that semantics matter, and might want to reconsider their use of language which might literally not ‘speak’ to a sizeable number of young scientists.

6.3c Weak Pragmatist

The weak pragmatists express uncertainty towards the construction of their scientific identity. Their game strategies reflect this uncertainty and are compromised by it. The weak pragmatists - Rosie, Rich, Laurie, Charlie, Jack - share in common an initial or ongoing aspiration of becoming an academic. However, exposure to academia, through their PhD, has weakened their confidence of this foremost ambition being realised. The weak pragmatists came to view academia as a game in which the ‘*survival of the fittest*’ principle is most severely applied. Consequently, the weak pragmatists are united by their adoption of combinatorial game strategy, in which strategies that open up outcomes in addition to the first choice are considered.

Charlie’s strategy was rooted in an uncertainty over whether he would be good enough to attain a postdoc (7). Such explanations relating to the person demonstrate that academia is thought of as an *uneven* game; not all players are of a comparable standard and some have more favourable odds of achieving their desired outcome. Other weak pragmatists sought structural explanations for their strategies: Rosie talked about the need to keep an open-mind and be flexible in the current economic climate (9); Jack, who admitted that money was a motivating factor for him, said he would weigh up his options according to their financial prospects (15). Rich stated that he simply didn’t want to place his entire effort towards a career path where the odds of getting a job were dauntingly poor. He explained:

You generally start a PhD wanting to go on to academia, and then a year or so in you suddenly sit up and realise, 'hang on a minute, there's 30 to 40 people here, scrambling

around for one professorship. My odds aren't great'. You can have all the self-confidence in the world, but if you actually sit up and look at the fact of this, that kind of ratio. The number of PhD studentships seems to have increased without the corresponding increase in the number of positions for us to go on to.

(Rich: 2)

Thus the weak pragmatists remained hopeful that an academic career would be open to them, but they had begun to think of alternative ideas. Subsequently, they can be said to be adhering to the notion of a combinatorial game, in which acceptable outcomes are numerous, though perhaps not equal in preference. As a result, formulating a strategy for a combinatorial game is complicated because it implies a conflict of interests and an unresolved decision. Nonetheless, it is plausible to argue that despite the discomfort that navigating uncertainty will no doubt bring to the weak pragmatists, they are on the whole in a better position than the scientific purists or the socially-oriented, who are set on more fixed courses of action. The weak pragmatists have deployed their observations and reflections of academic life to the strength of their game strategy. A combinatorial game is likely to be lower-risk than the zero-sum, 'all or nothing' strategies of the scientific purists and socially-oriented young scientists; the weak pragmatists can thus be said to hold both a more cautious attitude to risk, and a more realistic outlook on scientific life.

In light of the combinatorial game before them, the weak pragmatists can be said to follow a *maximin* principle. Simply put, the maximin strategy is akin to '*hoping for the best*'. A maximin strategy, identified by von Neumann, is a common response in games where the odds of achieving a preferred outcome are uncertain (Binmore: 30). The maximin weak pragmatists are enlightened as to the scarcity of academic jobs, but they decide that the optimal strategy involves investing most of their efforts into securing an academic job. The maximin strategy is about avoiding worst case scenarios. The weak pragmatists continue to prize an academic job above all other types of scientific career; thus, the worst case scenario in this incidence would be the failure to secure an academic job. The weak pragmatists are aware that their worst case scenario is a very real possibility - something that cannot be said for the scientific purists and the socially-oriented. However, they decide that the most robust strategy to prevent the worst case scenario from occurring is to concentrate all of their efforts into becoming an academic postdoc, rather than investing critical energy into preparation for other, secondary career options.

Charlie, who it was earlier noted, harboured anxiety about his ability to be a postdoc nonetheless maintained that it remained his first choice career at present (7). Different however to the scientific purists, is Charlie's willingness to consider other contingent career options in the case that his first choice does not work out. Charlie spoke of his interest in science communication, and his frustration that current attempts to get the public interested in science inadvertently reinforced the distinction between 'scientists' and the 'public', simply by labeling the exercise 'public engagement':

It's just semantics. It just puts another - just separates things: here's the public which we need to engage. By nature, [it] puts a barrier up.

(Charlie: 7)

Despite these strong views, at the time of the interview Charlie only toyed with science communication as a secondary career option, explaining that '*it might suit my disposition*' (7). Furthermore, and in contradiction to his comments in the above quote, he saw science communication as something that he would do if he could not forge a career in academia (7). Thus Charlie is implicitly contributing to the barrier that he spoke of; in that he cognitively separates a career in science communication from a career in science. Showing a similar lack of reflection, and indicating that thoughts of career options other than academia had hitherto been neglected, Rosie suggested that she might become a primary school teacher after the PhD, before qualifying herself: '*no, that won't be challenging enough, not after all this*' (9). Later in the interview, she once again acknowledged the uncertainty surrounding an academic career, but made it clear that it was still where her thoughts and resources were being directed:

You can't like say ten years ago focus on something and hopefully you'll get that goal at the end. Now you've got to focus but you've got to have sort of plan B, C, D and E as well to cover the whole gambit. So you think okay I could do this, I could do this and I could do this. So it's just sort of spreading the options a bit more. But, the main focus is still to become a lecturer.

(Rosie: 10)

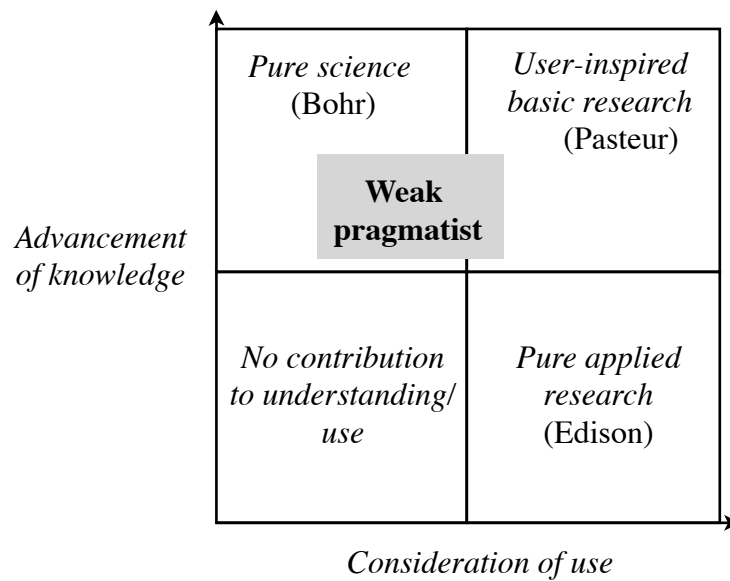
Clearly, attention is still focused primarily on an academic career; this is the advice of the maximin principle. Perhaps one should tolerate such ambiguity from the weak pragmatists; after all, there is only a very fine line between exhibiting flexibility and falling victim to a lack of focus. Other interviewees who had contemplated other career options in the case that academia did not work out included Rich, who had thought about the pros and cons of industry and finance:

I started my PhD saying, 'right I'm going towards a research career and then carry on in academia', and then, gradually got disillusioned with the whole thing. I thought, 'well I'm going to go into industry or I'm going to go into banking or I'm going to become an author, or, just anything to escape'. Then towards the end I actually kind of thought, 'well, actually [academia's] not so bad'. I'd tried engineering and I did vaguely try to get an interview with a bank but it fell through because their HR department was atrocious. Then the opportunity came up for the post I'm filling now and I took it.

(Rich: 13)

The 'post' that Rich is referring to was a postdoc at another university, which had just begun at the time of our interview. Thus for Rich, playing the maximin strategy appeared to have worked, and he is demonstrably not entirely clueless as to where he could have applied for related work should his academic career not have got off to the same promising start, even though he had not considered these secondary options yet with any seriousness. Laurie knew that he had the desirable skills to work in an investment bank, but he was still hoping for a career in academia since it would allow for the interesting work that he so valued (12-13). In any case, for the duration of his PhD, he seemed committed to not making any decisions of closure regarding an academic career. Jack believed that a postdoc at the university remained one of his most lucrative options, and he spoke with admiration for a postdoc he knew who had managed to juggle academic research with consultancy for a business (14). Achieving that level of independence – and always having a contingency in case an academic career did not work out – seemed optimal to Jack, who did not want to return to his civil service job. Thus we see the weak pragmatists play the maximin strategy on the basis of a crude distinction: academia is the first choice career and secondary options, though recognised as possibilities, remain just that – *secondary*.

The values of traditional academia – and an eagerness to protect them – are central to the weak pragmatists’ position. The flexibility of the weak pragmatists is represented on Pasteur’s quadrant below (figure 6.4).



Adapted from Stokes (1997)

Figure 6.4 The weak pragmatists and Pasteur’s quadrant

The weak pragmatists align most closely with the scientific ethos of Bohr; however, since they cannot deny thoughts of other possible careers, they can be seen to marginally creep into a more applied sector of the quadrant. Nevertheless, when they think of applied research, it is in terms of opportunities where it develops from initial, pure interest, and it would seem unlikely at this time that they would feel comfortable working with an Edisonian outlook. A systematic, theoretical approach, grounded in basic scientific knowledge remains integral to their view of good science, rather than a trial and error, market-focused routine (Jack: 3; Charlie: 8; Laurie: 12; Rich: 12).

The embeddedness of traditional academic values within the weak pragmatist psyche is further apparent in the emphasis that these doctoral students put upon publications as one of the most important outcomes of their PhD (Rich: 13; Charlie: 8). Laurie explained how publication is arguably the most important factor in setting oneself up for academic success; indeed, he believed it could even overturn one’s educational history or institutional allegiance.

Let’s say you go to some university that has a long name ending in all sorts of words. They tend to be not so great quality at undergrad but when you find a PhD student and

they've published their work it doesn't seem to matter so much what institution they came from. Yes, there's far more opportunity to be good enough to publish at [this university]. I'm not saying that [this university] isn't better but I'm saying that once you cross that threshold of publishing in a decent journal it's a bit more of a level playing field. Everyone seems to be good.

(Laurie: 13-14)

Similarly, all the weak pragmatists agreed upon the importance of academic freedom, and that it was an essential - if sometimes complicating – addition to the STEM PhD (Rosie: 4; Rich: 5; Laurie: 3; Jack: 7; Charlie: 6). Laurie in particular was keen to emphasise how important the provision for intellectual freedom would be as he weighed up future work options (12). This is reflective of the deep-rooted respect that the weak pragmatists had for the PhD as an institution; respect for its tradition, its symbolism and its structures. They believed that the traditional academic model of the PhD worked well, and they expressed no desire to reform it despite a reduced certainty over a future academic career (Rosie: 3; Jack: 4; Charlie: 3; Rich: 7). They trusted that it was preparing them well, and that the achievement of the qualification was central; both figuratively and practically, in their becoming as a professional scientist. It follows that the weak pragmatists exhibited a low-risk approach to knowledge production; staying close to the basic research section of Pasteur's quadrant in order to concentrate their efforts on research that academic science would value.

While the weak pragmatists suffer less from bounded rationality than the scientific purists, the weight of their moral position is still evident. An academic career remains their first choice; and this value judgement is central to their game strategy. We are getting a sense of the constraining effect of the hermeneutic circle of scientific identity; in that it enforces a consensus between normative values and career choices. To an extent, this entrapment is not unique to the young scientist: moral positions, access to information, cognitive ability, and the job market are variables that constrain us all as we plan our career. However, it is possible to adopt a more malleable approach to these issues as we will now see with the strategies of the strong pragmatists.

6.3d Strong Pragmatist

The strong pragmatists – Isabelle, Daniel, Simon, Dylan, George and Thomas - generate one of the more interesting displays of a strategic game plan as they reflect upon their experience of the PhD.

Isabelle and Daniel had started the PhD thinking that they were destined to become university academics (Isabelle: 8; Daniel: 5), but with time this aspiration was revealed to be less firm than it was for the scientific purists, socially-oriented and weak pragmatists. Isabelle and Daniel instead began to think of themselves as ‘researchers’ in a far broader sense as their PhDs progressed. Isabelle, for example, was aware of corporate opportunities relating to her work and spoke of the appeal that team-work in an industrial setting held for her (Isabelle: 4, 8). Daniel spoke of a similar newly-broadened perspective on careers:

Since starting here I've actually changed what I thought my PhD was preparing me for. I always used to think the PhD was preparing me for an academic career in science, I actually don't think that at all anymore. I think it's preparing me to be a researcher – someone who thinks scientifically, and works scientifically. I think it's also preparing me to... do something much more industry based... having a set problem from a company and knowing I can solve it.

(Daniel: 5, 6)

While Isabelle continues to contemplate an academic career (8), Daniel's identity has undergone a grander transformation; he now doubts that academia is the career trajectory for him. Simon and Thomas' doctoral journeys are more complex to trace, because both admit to beginning the PhD with no fixed career plans. Simon spoke of the PhD as preparation for a ‘*career in research*’, and how his year of industrial research opened his eyes to the usefulness of a PhD in contexts other than academia (3). Thomas admitted that he had started the PhD with no expectation other than that it would prepare him for a career in research, broadly construed (9). Thomas had expected to pursue a research career within the discipline of his PhD - physics; however even this certainty was chipped away through the course of his doctorate. He spoke of the closure of his lab and how this had encouraged him to ‘*re-think my career path*’ (9). He had consequently focused upon the development of different skills, citing ‘*coding*’ as an example (9). The lab closure ignited Thomas's strong pragmatism; and as he reassessed his ambitions, a desire for family life and ‘*a job that pays quite well*’ moved up his priority list (4). George excluded himself from the likelihood of forging an academic career because he thought he had an unsuitable personality for it (9); in similar terms, Dylan was put off by the teaching and administrative duties of academic life, and looked to other sites of scientific knowledge production that he deemed to be more personally suitable (8).

The strong pragmatists have the most cautious attitude to risk that we have seen thus far; hence they investigate as many career options as they can. They are not prepared to risk everything - their well-being, work-life balance, and chances in other professions - by committing themselves blindly to the single option of a career in academia. One might think that speaking of the 'moral position' of the strong pragmatist presents something of a paradox, since these individuals are clearly thinking broadly and will readily adapt for an attractive career option. On this issue, I would suggest that the underlying moral principle of the strong pragmatists is *utilitarianism*. The strong pragmatists are highly rational individuals who weigh up various courses of action and the odds associated with each outcome, before deciding upon their best strategy. By presenting science and the knowledge economy as of equal worth; in theory, no research job is off-limits. This method is identified in game theory as the *minimax* principle.

The minimax principle can be described as '*preparing for the worst*'. The strong pragmatists do not abandon all hope of securing an academic job, but their *modus operandi* is to assume that they will not. Thus, they duly invest their resources into exploring other career options. In contrast with the weak pragmatists, they do not passively '*hope for the best*'. The minimax principle requires proactive behaviour from the strong pragmatists so as to ensure that their specific PhD experience bolsters their candidacy for non-academic options. Thus, we see Thomas' initiative to develop coding skills that were not featured in his original project; Dylan and Simon investing time in improving the transferable skills that they believe industry will value, such as lay communication of complex information (Dylan: 7; Simon: 8); Daniel, who took seriously the transferable skills courses offered by the university's graduate school, and found comfort in the realisation of his diverse skills-set (6, 7); and Isabelle, whose strategy was to test out different research environments before making a more final decision about whether a lecturer position best suited her, as she had first thought (8). George was less sure of how well his PhD prepared him to transfer his scientific skills and knowledge to other contexts, and cited instead his ability to '*learn very quickly*' - a trait that he believed left him '*slightly fearless*' about applying for almost any work (9). Dylan described himself as '*a pure research person*' (8), and for him, a worst case scenario implied losing the freedom to conduct pure research. He understood that by selecting only academia as a career option, the opportunities for pure research work may be limited. Therefore, '*conducting pure research*' was the preferred outcome of Dylan's strategy; to an extent, the context - academia or industry - was of secondary importance (8). Preparing himself for the worst case scenario - that academia may not

offer him a pure research role – Dylan opened himself up alternative careers; hence playing a clear minimax strategy.

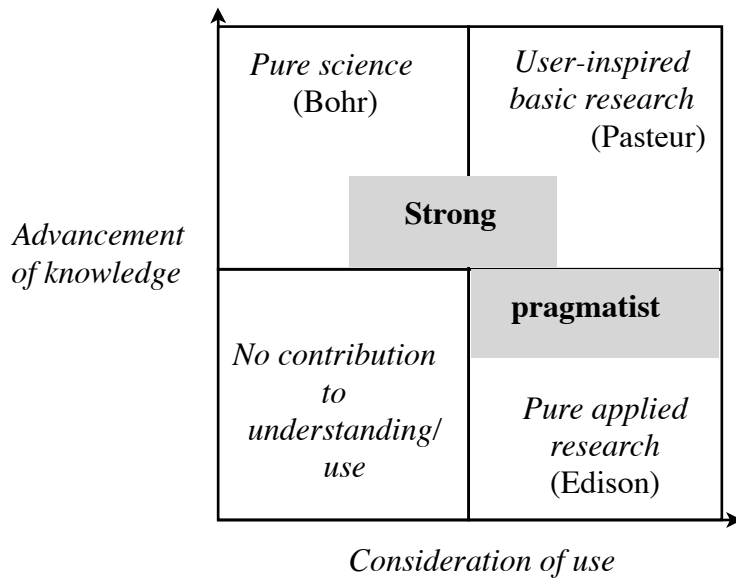
In game theory literature, the minimax principle has been viewed negatively - as something that *'only a paranoid would find attractive'* (Binmore: 31). The rationale for this is that it can lead an individual to overestimate their chances of failure in securing a desired outcome. Nevertheless, in the academic context one cannot help but feel that strong pragmatism is actually a rather sensible game strategy. There is of course the danger that a comparatively talented young scientist may underestimate their suitability for an academic career. From the perspective of funders in the UK however - the government and industry in particular - it is neither expected nor desired for most STEM PhD graduates to stay in academia after completing their doctorate. The strong pragmatists are therefore the most in tune of all the young scientists discussed so far with the reality of the economic position of STEM PhD holders and the variety of appropriate jobs. The great advantage that the strong pragmatists have is that they fully appreciate the number of options open to them, and crucially, they do not feel any stigma attached to leaving the academy.

The strong pragmatists agreed that in terms of day to day PhD research, the most important strategy involved focusing upon the production of scientific knowledge, to their best ability. All strong pragmatists agreed that they contributed to intellectual innovation, and that commercial innovations would interest them as their career progressed. For the moment, they conceived of the PhD as about ensuring that they had the basic, transferable skills which could be capitalised upon later (Simon: 9; Thomas: 10; Isabelle: 7, 8; Dylan: 7; George: 9). As Daniel commented:

A large part of my work is bringing together what other people have already done, and I feel at the end of this, I will be able to offer people a new tool to use, which is a nice innovation for those what want to use it. If not, then the skills I have got will also enable me to go out into a new research environment and innovate there.

(Daniel: 10-11).

When placed in Pasteur's quadrant (6.5), the versatility of the strong pragmatists is clear to see.



Adapted from Stokes (1997)

Figure 6.5 The strong pragmatists and Pasteur’s quadrant

We can see that for the present, the strong pragmatists are mostly focused on basic science, but they expect it is likely that they will at some point move into the sections relating to user-inspired or pure applied research. The strong pragmatists cherished their adaptability which included a broad appreciation of different knowledge types and their distinct values.

None of the strong pragmatists were engaged in external collaborations as part of their doctorate, but they acknowledged the possibility of moving into private research. The immediate context of the STEM PhD remained focused upon the production of basic knowledge and the development of transferable skills, and so it is evident that the strong pragmatists held onto some traditional views of the PhD and academia. Publications remained important to them; valued as indicators of their research abilities, which could then be demonstrated to an academic or non-academic employer (Simon: 3; Thomas: 8; Dylan: 17). Daniel thought that having at least one published paper was a silent rule for passing the viva, and so he continued to focus upon his publications record, despite envisaging an industrial career post-PhD (14). Isabelle believed that producing the best possible academic PhD, together with a commensurate publication record, would heighten her employability in all sectors (Isabelle: 7). This sentiment is interesting because it will be shown in the next section that the third-order capitalists - who saw themselves bound for a career outside of academia – greatly disagreed with the strong pragmatists on this point.

Timely completion of a respected thesis was important for all the strong pragmatists - except for Simon, whose lack of confidence led him to claim:

It's only [in] the last couple of years [that] I thought, you know, [I] might study for a PhD, so, as far as my career is concerned, it wouldn't be a complete disaster if I didn't get it.

(Simon: 4)

The impetus of producing a solid piece of scientific work in the PhD meant that the strong pragmatists defended the importance of academic freedom during this time. While the strong pragmatists might imagine working with interested stakeholders later in their career, for the time being, academic freedom – met with responsive supervision – was deemed essential for the development of the skills expected of an independent researcher (Simon: 4; Thomas: 6; Isabelle: 5; Dylan: 11). George described the freedom of the PhD as one of its ‘*great joys*’, providing that it was balanced with adequate supervision when times were hard (7). Daniel concurred:

You need to be given a large play-pen to go around in. So you have a significant degree of space, but there are also firm barriers at the edge of it.

(Daniel: 5)

In sum, the strong pragmatists provide one of the clearest examples of a game strategy developed during the STEM PhD. These young scientists display a commitment to utility first and foremost. The strong pragmatists uphold the importance of academic freedom throughout the training period that is the STEM PhD, but thereafter they are prepared to be flexible as they carve out their future career. The resultant scientific identity accepts the equal standing of knowledge economy science and academic science; and is prepared to shift as required to the numerous spaces in which a contemporary scientific career may be forged. The strong pragmatists have developed a sophisticated and malleable way of thinking about their future scientific careers, and it seems likely that their informed responsiveness to the various contingencies of the different spaces of science will leave them well disposed to profit from future academic or knowledge economy opportunities. The one limitation of the strong pragmatists’ position is that they appear to conceive of it as a short-term strategy; a coping mechanism for the present uncertainty of their doctorate. Ultimately, they

still aspire to the security of a clearly-defined career path and corresponding professional identity. In the next chapter (7), I argue that all contemporary young scientists would do well to assume the flexible attitude of the strong pragmatists for the duration of their entire scientific career.

6.3e *Third-order capitalist*

The self-interest of the third-order capitalists - Will, Mohammed, Toru and Graham - involved securing a successful career outside of academia; precisely within jobs that would be recognised as 'knowledge economy' roles. The proverb of the third-order capitalists was that a career outside academia was superior to one in it, and so pursuing a strategy to ensure that their STEM PhD led to a satisfying and well-paid industry job presented no moral dilemma; rather, it complemented the cornerstone of their scientific identity. The third-order capitalists recognised information as paramount to forging a successful industry career. All four students were confident communicators and their beliefs were grounded upon real-world experience and examples. Being positioned in the slightly older age bracket of interviewees (26-30), and with combined experience working in industry and finance between undergraduate and postgraduate study, the third-order capitalists felt that their odds of an effortless transition into industry after the PhD were certainly advantageous when compared with their younger and less experienced fellow students.

For the third-order capitalists, the experience of the STEM PhD enabled a taste of academic life, from which they ascertained it was not for them. These individuals exhibited thoughtful reflection of what an academic career would be like; they *could* pursue it, should they so want, but preference rather than expressions of inability had persuaded them otherwise. Mohammed, for example, memorably stated that academia was '*not for the fainthearted*', and that if an individual was going to put themselves through such a stressful working life, they may as well seek greater praise and remuneration than academia offered (12). Similarly, Will spoke of the possibility of becoming a part-time '*honorary industrial fellow*' at the university, but this was not his primary intention (10). As for all the third-order capitalists, a lucrative career in industry was regarded as the first choice. Graham had chosen the topic of his PhD research specifically with an industrial career in mind, and though he admitted that employers might not see the benefits of hiring a PhD, he had no doubts that he would have no trouble finding a job, and that once employed, he would excel (9). Toru was less sure that his specific PhD topic of medical engineering would be wholly relevant in his future career, but trusted that the transferable skills he developed would be valued – particularly if he

followed through his plan of moving to America, specifically to seek industrial work for a research-orientated employer who he thought would place a '*certain level of trust*' in his qualification (7).

The third-order capitalists believed that they had developed a highly robust strategy. They did not perceive themselves as risk-takers. On the contrary, they believed that there were more risks involved - poor working conditions, job insecurity, futile research - in staying in academia. Everyone in academia may have a PhD; but, in the outside world, PhDs remain relatively rare. The third order capitalists believed that the PhD qualification, combined with appropriate industrial experience, offered a low-risk passport towards professional and commercial success. The doctorate was thus an important time to foster and maintain links with industry, and each third-order capitalist reported an intentional strategy of doing so. Therefore, acts of cooperation in the third-order capitalists' strategy, are directed toward industry. For Will, this was relatively easy. His employer funded his PhD and the core of his project was focused upon solving his company's problems. Indeed, he wouldn't have had it any other way; he wanted to do a PhD that allowed him to stay part of the company and that he believed would lead to a promotion upon its completion (10). Toru spoke of his continued communication with potential employers and former workmates. He stated the importance of regularly taking stock, to ensure that continuing with the PhD really was the optimal strategy in terms of securing the career he hoped for afterwards. He had stayed with the PhD thus far because of the way in which he felt his analytical skills were being invaluablely developed.

I still get bombarded by head hunters asking, 'Have you done your PhD, have you finished or are you thinking of just going back into employment?' So I have to always reassess: 'Okay, do I continue or do I just leave', but I think looking back it's been a very good process. [I'm] always trying to think outside the box, which maybe an undergraduate degree doesn't necessarily teach you.

(Toru: 3)

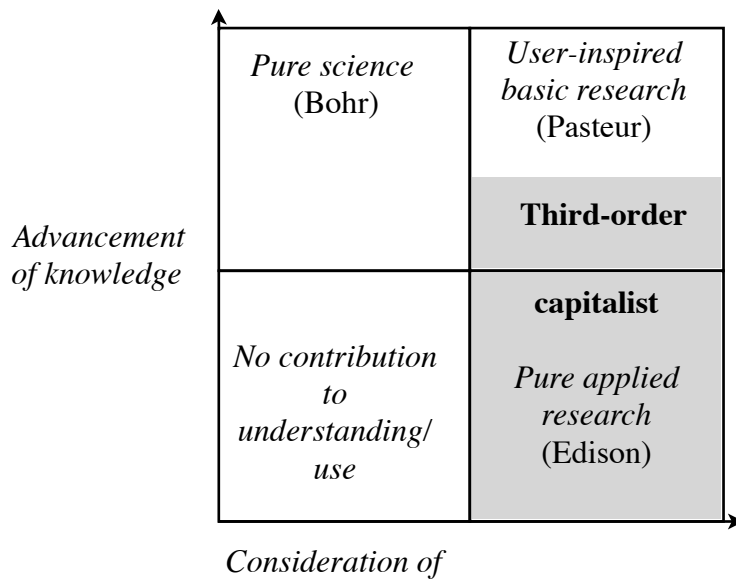
The specific environment of their university was taken into account as the third-order capitalists thought about their game strategies and prospects. Mohammed in particular saw the university as a serious obstacle to him achieving his aspirations. He spoke of the costly overheads which deterred industry from coming into his department to conduct collaborative research (2), and also of the poor equipment on offer for PhD students which, not being of industry standard, left them ill-prepared

for industry (16). Will agreed with this point about the substandard facilities of universities (4); but was more scathing of the cultural factors of academia which deadened its relationship with industry. He spoke of PhD students in his department being able to carry out research that would never be of interest to industry and – whether they realised it or not – would damage their employability at least as far as industrial R&D was concerned (7). He lamented the lack of energy around the college (6), and questioned the ethics of an organisation that allowed the career of an individual supervisor to profit at the expense of the hard-work of largely unrecognised PhD students (11). Mohammed concurred that most PhD students are used to boost the publication records of their supervisors, and he was determined not to be subordinated to these purposes (8). It is interesting to note the boldness of the third-order capitalists' position on publications. It is well documented that publication records are considered a measure of academic performance, and that consequently, promotions and funding allocations correlate to high publication records. That senior researchers often benefit the most professionally through co-authorship, while early-career scientists do most of the work and have the least to gain, is a recognised trend of contemporary academic life (Lawrence, 2002). The reason that this '*rank injustice*' continues is because early-career researchers often feel as though they have to accept the rules set by their elders in order to lay the foundations of a successful scientific career (Lawrence, 2002: 836). This certainly seems to be the case in the strategies of all the young scientists we have discussed so far, who see publications and a good working relationship with their supervisor as key to their future success. The third-order capitalists stand out for their rejection of this system. Nevertheless, their rejection of '*exploiting of [the] young*' - refreshing though it is - is arguably far easier given their intention to leave the university upon completion of their PhD (Ibid.).

For Mohammed, fighting back against the perceived injustice meant developing a proactive strategy with the optimisation of his career in mind. He recounted how he had changed his PhD project, having become fed up with his supervisor's continual interventions and how he had actively shaped a multidisciplinary project for himself, since he believed this would be more relevant to the real-world and thus boost his employability (7, 10). He spoke of the project management and team-work skills that a multi-disciplinary PhD had enabled him to develop. His efforts appeared to have paid off; at the time of our interview, nearing the end of his PhD, a multi-national telecommunications corporation had approached him regarding the possibility of consultancy and further research work (11). Will agreed that STEM doctoral students needed to do more to pitch their work to companies, but that the mindset of the university and academia more generally did not encourage this. For Will,

as I have already documented, the root of the problem lay in academia's fixation with publications as the measure of intellectual prowess and scientific accomplishment.

Mohammed shared Will's cynicism of publications by suggesting that they were primarily for the benefit of supervisors (8). Toru admitted that publications were a mark of acceptance into the academic community, but that they were not a central concern for him – they built up slowly as a consequence of the practical problem he was trying to solve (3). Graham expressed no preoccupation with publications – a notable difference to the other young scientists; indeed, he went as far to say that the thesis itself was merely an '*administrative overhead*' and that his knowledge and skills - not the paper qualification - would consolidate the fortune of his future career (3). For Graham, publications and the thesis stood in the way of getting the research questions answered; they were certainly not necessary components of the problem-solving process. Like Graham, Will had little regard for publications because he considered them to be distinct from the reality of science; and moreover, at odd with an ambitious working style associated with novel and groundbreaking knowledge creation. He explained, '*people don't ask hard questions. They just publish what they can*' (2), before saying of a fellow PhD student in his department, '*looking at [the] papers he's now publishing, they're not important. He's not actually solving the problems; he's just publishing stuff*' (3). The third-order capitalists shared the conviction that publications would not be decisive in their strategy to reach the desired outcome of an industrial career, and so with regard to Pasteur's quadrant below (figure 6.6), they are located at the overlap of the top and lower right-hand squares: valuing user-inspired basic research and pure applied research.



Adapted from Stokes (1997)

Figure 6.6 The third-order capitalists and Pasteur’s quadrant

Thomas Edison speaks most strongly to the third-order capitalists; he was at once a scientist and a businessman, who shaped his research around consumer demands. This approach certainly chimes with that of Will, Mohammed and Graham – who were all keen to apply their scientific knowledge to the corporate world. Toru’s PhD research however proved that preparing one’s skills for industry need not preclude the possibility of doing some social good also; his specialism of medical engineering is more closely aligned with the work of chemist and microbiologist Louis Pasteur, whose work in the prevention of diseases secured his place in scientific history. Having said this, Toru did envisage a turn towards a private employer having completed his PhD. Will was especially vocal about the need to reform the PhD so that more Edison-inspired young scientists could truly make an impact through their work. He believed that as long as publications remained the dominant currency of academia, the prerequisite risk-taking of an inventor would not develop (2; 16). Will’s belief raises a serious question for the stakeholders of the knowledge economy: it may be the case that policy-maker and industry expectations that the PhD population will foster a new generation of scientist-entrepreneurs is mistaken if the sovereignty of publications is not challenged. The third-order capitalists do not let thoughts of publications nullify their imaginations or shape their strategy through the PhD. However, they are a minority in the interviewees, and report little support from the university or their supervisors within their strategic ambition to transform their STEM PhD into a site of preparation for industry.

Below, figure 6.7 shows a decision tree, typical of game theory analyses. It maps the individual trajectories of young scientists, with regard to some of the critical questions they face during the doctorate. We can see how normative values on science and professional aspirations lead to the five scientific identity types. Scientific identity is presented as a desired end-point at the final stage of the game; thus suggesting that many of the choices made by young scientists, and the values that they express with regard to these choices, can ultimately be explained in terms of the coherent scientific identity that they wish to construct for themselves. The impression of being bound and driven by a commitment to a particular scientific identity evokes the situation of the hermeneutic circle introduced to us in 5a, where we saw how, fundamentally, all that we learn about young scientists and the knowledge economy, takes us back to the issue of scientific identity.

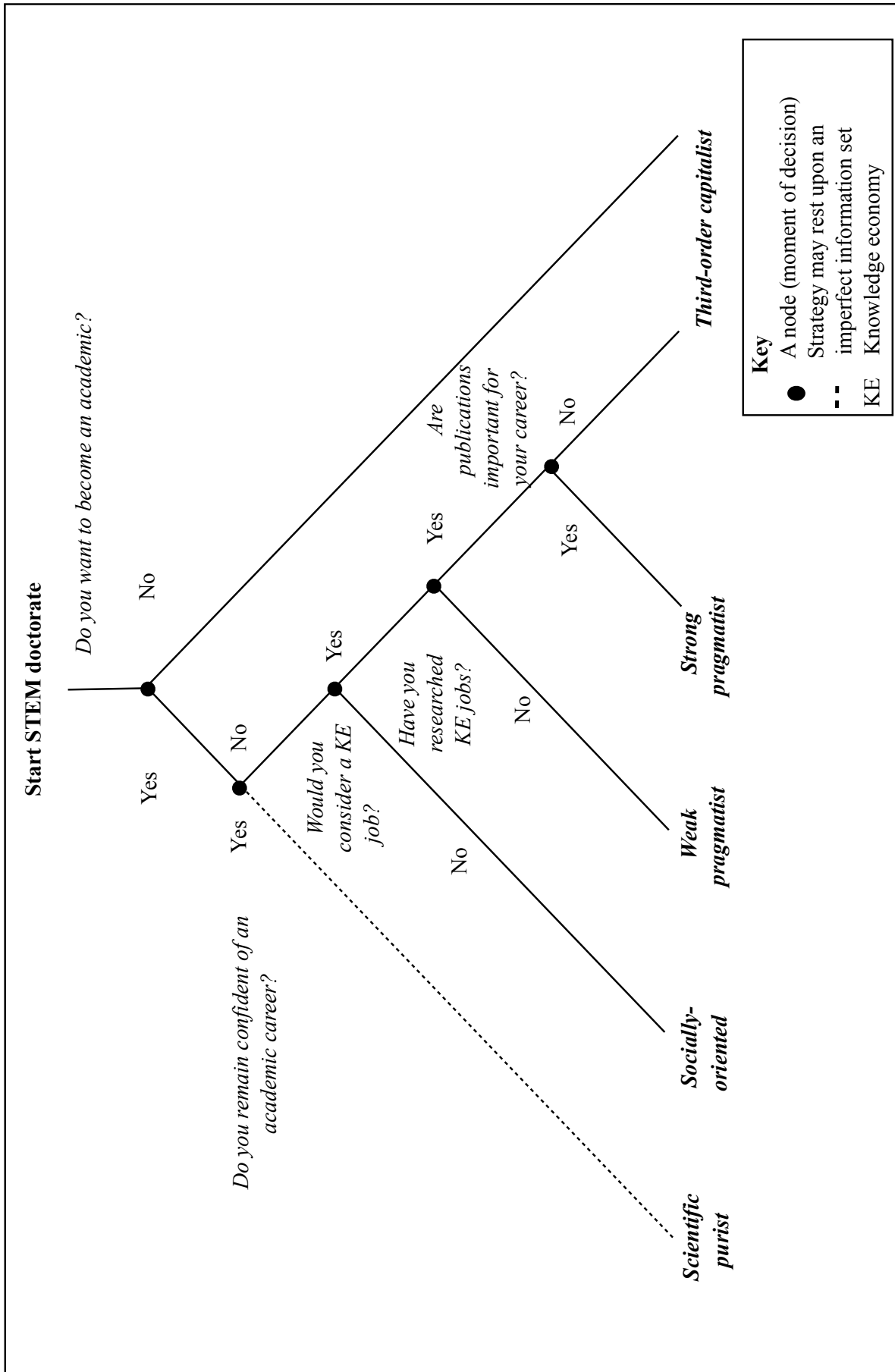


Figure 6.7 The game of the STEM doctorate

6.4 Conclusion

I have demonstrated in this chapter the diverse and distinct game strategies that young scientists exhibit in relation to their thoughts on the knowledge economy, scientific identity and science more broadly. In taking this approach I have looked beyond the communities of practice model, which is regularly employed in educational theory to understand the socialisation of newer researchers into a field of experts. In particular, I take objection to the assumptions of COP that the STEM doctorate is primarily a social experience; that identity construction occurs with reference to close-knit network of professional peers; and that completion of the PhD signals the safe-passage into a community of experts.

I have argued that game theory supersedes COP as an analytical tool for understanding identity construction at the time of the STEM PhD. The primary strengths of the game theory analysis are fourfold. First, it exposes the *individual* nature of each young scientists' doctoral journey. Second, it emphasises the intensely *competitive* environment that young scientists inhabit. Third, it allows us to examine in detail the strategic *decision-making processes* that enable young scientists to construct a particular scientific identity. Fourth, it reveals how identity construction is based upon values but also calculations of *risk* and *probability*. It can be argued that any analysis that rests upon participants' responses - rather than participation observation - is, in a sense, reductive; however I believe game theory offers a deep insight into the experiences of young scientists. Consistent with grounded theory, all assertions made in this analysis are anchored in the data provided by young scientists, and so, they emerge entirely from the perspective of young scientists. Game theory is but one way of telling their story; psychoanalysis would, for example, make for an interesting alternative. As per the hermeneutic tradition, I selected game theory because of my strengths as a researcher with a background in political science, but also because of the aforementioned four aspects of young scientists' identity construction that this analysis brings to the fore.

On reflection, I believe that the discovery of young scientists' strategic and individualistic thinking is a positive one. There is a chance that a proactive approach may serve them well in uncertain times, and it is reminiscent of the sort of entrepreneurialism that the UK government, business and universities have sought to encourage in young scientists. Game theory arguably encourages thinking about the individual in evolutionary terms; and devising a wise strategy may ensure that young scientists heighten their chances of success by playing along with the rules of the system that they find themselves within.

The game theory analysis raises questions about those young scientists who see no incentive in the knowledge economy and do not develop a strategy aimed at becoming part of it. Stakeholders of the knowledge economy might wish to use this insight into the desired outcomes of these individuals in order to think about how the science and values that incentivise the scientific purists and the socially-oriented young scientists might be built into the knowledge economy, thereby making it a welcoming space for them to consider a scientific career. Morality and values inform the students' strategies and the game theory analysis provides just further evidence that the knowledge economy can only be attractive to young scientists when it fits with their judgements on good science and a desirable scientific identity.

Also of concern is the evidence of poor information sets and the possibility that some young scientists may face great disappointment, and risk narrowing their employability, if their game strategies do not pay off. I say this with particular reference to the scientific purists and the socially-oriented. A consideration of how to improve young scientists' game strategies raises the question of how many opportunities these researchers currently receive during their doctoral journey to work out informed personal strategies. My suggestion is that at present, this space is insufficient – as is the provision of the necessary information for formulating a promising individual game strategy. At the time, the interviews I conducted seemed to be treated as much-welcomed spaces for these strategies to be discussed; I would argue that given the complexity and uncertainty facing contemporary young scientists, UK universities need to do more to assist with the burden of decision-making and address decisions made upon imperfect information. Any such guidance must also take into account that unlike generic career planning; these strategies are highly individual and must complement a moral position and an expressed scientific identity, as well as playing to individual strengths and weaknesses.

On a final note I would add that despite the different aspirations and strategies of the young scientists, not one interviewee suggested that the PhD was a source of regret, a waste of time, or that there might be a better way to deliver their preferred outcome. Thus, despite the multitude of strategies and preferred outcomes, the STEM PhD is still seen as the preparatory game of choice for future scientists.

Chapter 7. Scientific identity for the knowledge economy

7.1 Introduction

The purpose of this chapter is to bring together the thesis findings, and to answer research question three: *How do the knowledge economy, and young scientists' moral positions towards it, impact upon their understanding and construction of scientific identity?* I begin by revisiting the literature, with the question of scientific identity specifically in mind (7.2). Next, I conceptualise the nature of young scientists' narratives of their scientific identity, and I conclude that these narratives complement the paradigm of modernity (7.3). I see the paradigm of modernity as an outdated and contradictory model to that of the knowledge economy; therefore, the question arises of how well a modern scientific identity will serve young scientists in the knowledge economy?

In the final section of the chapter (7.4), I seek to answer this question. I argue that at present, higher education policy and UK universities are compliant in encouraging young scientists' towards a modern scientific identity. While I acknowledge the success of the Roberts' agenda and transferable skills training courses in raising young scientists' awareness of the versatility of their skills and knowledge, I suggest that universities now need to progress from these foundations. All types of science - within and outside of the university - are changing in light of the knowledge economy, and young scientists need more than transferable skills training to prepare them for the scientific careers that await. As we have seen, skills and knowledge are only one part of scientific identity; young scientists' normative understandings of science and the university also need to move beyond the modern model if they are to be prepared for the demands of the knowledge economy. I propose that young scientists ought to be nurtured to develop a *liquid* scientific identity, and suggest three reforms to the contemporary STEM PhD to facilitate this.

7.2 Revisiting the literature: the changing epistemic criteria of scientific knowledge production

Before we embark upon our consideration of scientific identity for the knowledge economy, and of the STEM PhD as a site of preparation for the knowledge economy, it is necessary to revisit the literature on scientific knowledge production; this time, with the issue of scientific identity more prominently in mind. I argue that there are two epistemological forces set to frame the short to long term future of scientific knowledge production, and thus, scientific identity. The first is the knowledge economy, and from chapter two we ought to be familiar with its epistemological nature.

The second, however, is *liquid modernity*, and it is in this chapter that we are properly introduced to it for the first time. Liquid modernity presents a different yet simultaneous epistemological challenge to the knowledge economy. The knowledge economy and liquid modernity will yield complex and significant influence over the research lives of young scientists as they pass through their careers; thus, the epistemic criteria of each must be properly understood before we can begin our contemplation of a scientific identity fit to cope with them.

7.2a *The knowledge economy: the contemporary grand narrative of scientific knowledge production*

Chapter two exposed to us the policy narrative of the knowledge economy: a seemingly infallible, progress-obsessed grand narrative; the influence of which shows no sign of abating in the short to medium term. The survey data reported in chapter five revealed that its expected symptoms now form part of the research lives of STEM doctoral students, and thus the knowledge economy, as both a normative construct of science, and a tangible phenomenon, ought to be built into young scientists' considerations of their scientific identity. Certainly, it is not possible to deny the presence and impact of the knowledge economy upon the individual scientist or the contemporary university.

Undoubtedly therefore, the knowledge economy should be taken seriously by young scientists as they work towards their doctorate within the university, and contemplate their future scientific career beyond it. What then, can be said of the knowledge economy? What would young scientists need to learn if they were to construct a scientific identity that encompassed a sophisticated understanding of the knowledge economy, and its implications for their future career? As we prepare for our discussion of a scientific identity fit to handle the epistemic criteria of the knowledge economy, two of its tensions stand out as essential prior considerations.

The first tension is that between the *omnipotent facade* and the *contingent reality* of the knowledge economy. It was argued in chapter two that the policy narrative homogenises understandings of the knowledge economy. The policy narrative is thus something of an omnipotent facade, in that it strives to provide a comprehensive description of, and orthodox framework for, contemporary scientific knowledge production. The ascendancy of capitalism seems undisputed and the policy narrative of the knowledge economy rides on this wave of self-assured power by proclaiming the necessity of new knowledge for continued prosperous enterprise. We are told that the knowledge economy is universal; further cementing its apparently unshakable and inevitable dominance. The

tactic of inciting fear, evident in Tony Blair's 'Knowledge 2000' conference speech is purposeful; if we do not accept the knowledge economy, we will be '*outpaced, and left behind*' (Blair, 2000).

Masked by this omnipotent facade however; is a contingent reality. As the work of post-structuralists, notably Derrida and later Lyotard, revealed, grand narratives do not, despite their assertions, rest upon universal truths. The elevation of a narrative to 'grand' depends rather upon a favourable contingent power basis. Put another way, the policy narrative of the knowledge economy is simply *one* way of telling a story about knowledge production; albeit currently, one that is popular with those in power. The contemporary dominance of the knowledge economy narrative owes less to its validity or truthfulness; and far more, to its power basis. The knowledge economy is to be taken seriously by young scientists as a determining influence in their present and future scientific lives; but only, they must understand, because it has been promoted by the majority of governments of advanced economies and relayed by acquiescent universities. The research intensive UK institution featured in this study is shown to have responded to the rhetoric of the knowledge economy with a fitting vocabulary, emphasising its '*excellence*' and global competitiveness (2012).

On the one hand, young scientists must appreciate that the narrative and policies of the knowledge economy have come to saturate spaces of scientific knowledge production, and must, to an extent, be worked *with*. On the other hand, it is important also that they grasp the politics of power that underpin the current authority of the knowledge economy, and that they perceive its partiality and finiteness as a way of thinking about science and the role of the scientist. Simply put, there ought, within scientific identity, to be a space for performative compliance with the knowledge economy, and a separate space for critical appraisal. The knowledge economy will fail, as all previous grand narratives have, in its totalising aspirations; therefore it is most important that while the knowledge economy must be worked with in order to obtain resources, young scientists are not blind to the temporal political contingencies which make it, in many ways, a rather vulnerable phenomenon. Young scientists ought to have a view of science that accommodates the knowledge economy, but is ultimately *more* than it.

The second tension that scientific identity for the knowledge economy needs to address lies between the *modern facade* and *non-modern reality* of the knowledge economy. This is a tension that will become less avoidable as the knowledge economy develops. In its display as a grand

narrative, the policy narrative of the knowledge economy exhibits the hallmarks of a *modern* system of understanding. Its modern characteristics are clear in its ambition to fulfil a total, universal system for the production, use and value of knowledge; and also in its presentation of knowledge acquisition as a teleological process. The sheer accumulation of knowledge was the modern mark of progress; it was assumed that knowledge amassed over time furnished understanding and certainty. As the world reveals itself, risks are lowered, and economic wealth abounds. This is clearly the antithesis of postmodern accounts of knowledge; wherein the accumulation of knowledge exposes to us the limits of human understanding. The postmodern purpose of knowledge is, in Foucault's words, '*for cutting*' (Foucault, 1986: 88). This disruptive account of knowledge's effects leaves little confidence that greater knowledge equals greater certainty or greater economic wealth, as the ongoing global financial crisis reflects.

The knowledge economy is shown therefore to rely upon a modern narrative of knowledge *and yet* - and herein lies the second tension - practically speaking, knowledge economies demand complex systems of scientific knowledge production, which tear away at the boundaries and dichotomies of the modern order. The knowledge economy, from a systems approach, can be described as most certainly *not* modern. The policy narrative of the knowledge economy may revive the language of modernity but it demands a non-modern system to achieve its objectives. The static modern demarcations between state, society, economy and the university fall apart in the knowledge economy. Protagonists of the knowledge economy tell us that knowledge production now occurs in a multitude of spaces that extend far beyond the modern imagination; in fact, many of these spaces are now *virtual* in essence. Knowledge workers are expected to flow freely across the institutions of state, academia or the R&D arm of a large multinational company. As far as education and knowledge is concerned, distinctions of 'public' and 'private' have come to lose all intelligent meaning (Ball, 2007).

For young scientists then, a recognition that behind the modern facade, a non-modern reality awaits must be accounted for in their scientific identity. As they forge their scientific careers, it is most likely that they will be expected to frequent all or many of the environments of scientific knowledge production within the ecosystem of the knowledge economy; and they will come to see that, despite their current assumptions, the university cannot be counted as existing separately to the knowledge economy. Cloaked within a narrative evocative of the modernist aims of growth, progress and certainty; the knowledge economy throws up a context for young scientists which is wholly *not*

modern. It is filled with movement, uncertainty, complexity, chaos and the merging of many paradigms. Young scientists will realise that there is a fundamental absence of security in the knowledge economy, and that achieving a sense of control in one's scientific life will come only from an understanding of the real choices and contradictions thrown up by the knowledge economy. Modern scientists may have been able to achieve success by focusing upon science alone; but for contemporary young scientists, success will rest also upon a grasp of the cultural complexity encompassing science. The future uncertainty that this complexity throws up is already beginning to impact on young scientists' well-being, as research from Walsh and Juniper at the host institution discovered in 2009. Interestingly, they found that most young scientists' selected the institution because they thought it would leave them *'better prepared for a research career'* (Walsh and Juniper, 2009). However, sometime into the PhD, the security of preparedness was not evident; *'being unclear about the next stage of your career after the PhD'* was revealed as the third most significant stressor detracting from young scientists' sense of well-being (Ibid.).

7.2b From modernity to liquid modernity

The policy narrative of the knowledge economy may throw up challenging contradictions for young scientists, but this pales somewhat when we consider a second epistemological force at play: that of liquid modernity.

Thinking back to chapter two of the literature review, I argued that the knowledge economy owed much to the postmodern turn. In particular, the happenstance of the postmodern turn provided an opportune moment for economic utility to replace 'truth' as the axiomatic imperative of scientific knowledge production. The narrative of the knowledge economy provided a coherent and compelling account as to why economic competitiveness demanded scientific knowledge; and so, it became an attractive version of events that the scientific community could subscribe to.

It could have been very different. The postmodern turn repudiated the notion of universal truths and a hierarchical structure of knowledge; meaning that all claims of knowledge were raised to the status of 'legitimate'. The expertise of trained scientists becomes no more valuable or powerful than the offerings of non-experts. The postmodern turn signalled the potential of a very serious crisis for the scientific community; or more precisely, for the *power* and *status* of the scientific community. The narrative of the knowledge economy arguably saved the day. By exchanging claims of 'truth'

for the banner of ‘efficiency’ and ‘profit’ - in other words, switching epistemological progress for economic progress - science could resume apparently untouched by the postmodern turn.

In reality, and as we have seen, this is not quite the case. The rise of the knowledge economy is a symptom of the postmodern turn, but the policies of the knowledge economy demand the development of a complex, identifiably *non*-modern system of scientific knowledge production. To an extent, the standing of science has been protected by the knowledge economy. The privileging of the STEM subjects in knowledge economy policy is indisputable. It translates into funding allocations that are markedly generous when pitched against the HASS subjects, which, it is claimed, are suffering a simultaneous ‘*crisis*’ in the knowledge economy (Collini, 2012: 63). Nonetheless, the narrative of the knowledge economy will not suffice as a universal frame of reference for young scientists constructing their scientific identity. The reason for this is that, as we have seen, despite the *omnipotent, modern facade*, the knowledge economy is complex and contradictory - a *contingent and non-modern phenomenon*.

The postmodern turn did not simply precede the knowledge economy. It also brought about the collapse of the modern period. I will argue that in place of modernity, the world in which the knowledge economy and young scientists exist, is *liquid modern*. Before defining liquid modernity and its implications, I will include a brief caveat to explain why the concept of *postmodernity* is limited in terms of the enlightenment that it can offer us in thinking about scientific identity.

To be clear I do not wish to challenge the occurrence of the postmodern turn. The postmodern turn brought an end to the modern period; a period governed by the grand narrative, and faith in universal, objective truths, discoverable through the scientific method - as per the story of the Enlightenment and the positivist research paradigm. However, looking beyond the postmodern turn, the temporal concept of ‘postmodernity’ is shown to be lacking; for three chief reasons that I will now present.

The first reason underpinning the limitation of postmodernism as an epistemological concept is traceable in the work of Bruno Latour. In his text *We have never been Modern*, Latour pertinently asks whether we can use the label *post*-modern, if in fact we were never modern. For Latour, the moderns were obsessed with temporality and consumed by false dichotomies; they viewed history and progress in terms of successive revolutions, and divided nature and society into separate

'ontological zones' (Latour, 1993: 10).³² From our present vantage point, we can see that Latour is correct in asserting modernity failed: the separation of subject and objects, of the natural and the social has become only more problematic with the advance of scientific knowledge. Conversely to the modern constitution, spaces where the natural and social coexist - that Latour terms '*hybrid networks*' - have proliferated (Latour: 10). The ensuing question that we thus face is whether, given our discovery of the '*outlived usefulness*' of modernity, we can rightfully classify the present era as postmodern? Latour says that we cannot. At the time of writing, over thirty years ago, Latour stated that our knowledge about the world sufficed only far enough to label it '*non-modern*' (Latour: 48). Shortly, I will argue why *liquid modern* is a better description of today's world; for now however, we can reflect on the illogical premise of calling the present 'post'-modern.

The second problem with using postmodern as a descriptive shorthand for the present is that by conceiving of present knowledge production as existing within a 'post' era, we do little to unchain ourselves from a temporally conceived, teleological notion of forwards progress; the conviction that the present is an improvement on the past, and that the future is brighter still. A continued reference to the temporal misses the point and true potential of the postmodern turn. As a conceptual tool, postmodernism ought to have taken us beyond hierarchical categories of knowledge and neo-liberal inspired visions of progress over time. The third and final justification for abandoning the postmodern rubric is that conceptually, postmodernism has proven to be an ultimately *destructive* tool for deconstructing knowledge claims and unearthing the power relations responsible for their perpetuation. Latour called postmodernism a '*symptom*' of modernity's demise, but not '*a fresh solution*'; and it seems as though he was right (Latour: 48). Instead of ending the age of the grand narrative, postmodernism inadvertently fostered another. Eschewing the modern constitution in favour of relativism, postmodernism left society bereft of a robust guard to prevent powerful interests from monopolising the production and application of knowledge, as the rise of the knowledge economy narrative reveals.

If we think of the present era as simply postmodern, it may seem as though the knowledge economy has triumphed and that the epistemic criteria of scientific knowledge production is ruled by this '*third-order*' of capitalism. This is too simplistic an appraisal. For something else has emerged from the postmodern turn. This is liquid modernity, and it is a force that young scientists will have to

³² An example of this being the temporal methodology employed by Kuhn in *The Structure of Scientific Revolutions*.

grapple with, in addition to the knowledge economy, as they construct their scientific identities and forge their scientific careers.

7.2c *Liquid modernity, liquid knowledge*

Liquid modernity, as its name suggests, is concerned with the *fluid, unstructured, and under-defined* condition that characterises contemporary society. Associated most readily with the sociologist Zygmunt Bauman, liquid modernity celebrates the potential freedom of the contemporary world structure, while alerting us to the inevitable discomfort of such a condition: contradictions; existential crises; incoherence; and, the lack of a guiding grand narrative (Bauman, [2000] 2012). Contemporary society may be freed; but the state of liberation lacks the basis - and sense of security - of the past orders (Ibid.: 16).

The policy narrative of the knowledge economy may at present appear to provide comfort and certainty as we attempt to fathom knowledge and the world; but the proponents of liquid modernity would warn us not to be so naïve. The animated and ceaseless critique of liquid modernity ensures that no grand narrative can exist with uninterrupted authority. Given that it offers us more freedom at the price of greater uncertainty, Bauman describes liquid modernity as a situation of '*mixed blessings*' (Bauman, [2000] 2012). Indeed, the careful title of his 1995 work *Life in Fragments* conveys the loss of structure and tension that punctuate life in the wake of the postmodern turn. For the interests of our present discussion, the most important consideration is that it is hard to imagine a future in which the fractured and disruptive forces of liquid modernity are somehow overruled; the irony being that it would take nothing short of a grand narrative to silence liquid modernity.

We saw in chapters five and six how young scientists' constructions of their identity hinge upon normative notions of good science. Liquid modernity has the potential to revolutionise traditional normative accounts of scientific knowledge production. For the higher education philosopher Ronald Barnett, the reality of liquid modernity, and its transformative effects for knowledge, cannot be overstated. Barnett tells us that liquid modernity is '*a situation of anarchic knowledge*' (Barnett, in Temple, 2011: 217). The challenge for the contemporary scientist is thus this: in order to function successfully, they must attain a degree of control amid lawless epistemological chaos. So in practice, liquid modernity means a total abandonment of prior modern ways of thinking about science. Exactly why this might be such a problem for young scientists is expounded more fully in the next section of this chapter (7.3); but for now, the point to note is that young scientists continue

to be informed by the paradigm of modernity when thinking about scientific identity and their future careers. The implication is that if young scientists do not respond to, and move with, the liquid modern reality, then their expectations and preparations will fast be proven as outdated.

The appropriateness of the *liquid* metaphor is elucidated when Barnett guides us through the freely flowing patterns that are to define the present and future of scientific knowledge production. He appeals to those involved in all manners of knowledge production and application to open their eyes to liquid modernity, and the urgent tone of his prose is worth quoting at length:

Off the leash of tight academic control and no longer confined within its strictly policed (disciplinary) borders, knowledge becomes much more fluid. Forms of knowing merge into each other... knowledge becomes less bounded: vertical knowledges give way to more horizontal knowledges....not simply interdisciplinary but...heterogeneous knowledge.

(Barnett, in Temple, 2011: 216)

The central argument of the present chapter is that young scientists are not encouraged to think about scientific knowledge production in this way, and consequently, they appear to be ill-prepared for the realities of the knowledge economy and liquid modernity. They continue to cling to identities that are shaped by modern disciplinary values, and rely upon unrealistic dichotomies when thinking about their roles as scientists. The five competing moral positions and associated articulations of what it means to be a scientist suggests that young scientists' willingness to engage with *'fluid'* or *'heterogeneous'* notions of science is an absent, or concealed, part of their scientific identity. For Barnett, scientists who do not understand or respond to liquid modernity will struggle to flourish. He pleads with those involved with knowledge production to embrace the ambiguity of liquid modernity, and seize the opportunity for creativity; beseeching researchers to become *'part-authors of their own epistemic experience'* (Ibid.).

The pervasiveness of liquid modernity means that it is beyond doubt that it will impinge upon the scientific lives of the young scientists. One example from Barnett's work illuminates the extent of its ubiquity. Liquid modernity is already beginning to chip away at the visage of coherence and authority of the policy narrative of the knowledge economy. In chapter two, I documented Gibbons et al.'s knowledge economy thesis marking the shift from mode 1 to mode 2 knowledge. Gibbons et

al. argued that this shift meant that the university has lost command as the central provider of legitimate knowledge; a position that it enjoyed unchallenged in the modern period. However, under the lens of liquid modernity, Gibbons et al.'s thesis soon seems incredibly short-sighted. Why, Barnett asks, do knowledge economy theorists propose that there are only two types of legitimate knowledge? Has not the *'epistemic genie'* now been unleashed? (Barnett, in Temple: 217)? What appeared to be a progressive part of the knowledge economy thesis is overturned by a liquid modern critique, and we can offer no plausible explanation for stopping at this arbitrary point, in the face of such epistemic restlessness. The question that interests us is what this means for young scientists? If, at the moment, they struggle to accept the simultaneous and equal legitimacy of modes 1 and 2 - tending to accept one or the other, as the extreme positions of the scientific purists and third-order capitalists demonstrate - how will they contend with a yet vaster range of knowledge claims? Especially when these claims will be impermanent in their eminence; gaining or losing influence amidst changing power relations within society.

The knowledge economy provokes difficult questions for scientific identity, but when set against the epistemic maelstrom of liquid modernity, it seems that even more disruptive forces await. The proposition that these forces are in some way ignorable does not hold: after all, the professional aim of the scientist is to further and deepen understanding. The most successful scientists of the future will be those who can navigate the tensions, and steer the ever changing tides, of liquid modernity; the growing contemporary trends of *'grantmanship'*, demonstrating the social and economic impact of publicly funded research, and showing a commitment to public engagement stand as evidence that the amoral, apolitical scientist of modernity is an out-of-date model.³³

While the policy narrative of the knowledge economy dictates the official rules of contemporary science, when set against liquid modernity, its long-term authority is questionable. Young scientists at the start of their scientific life should understand the co-existence of these two antithetical forces that weigh in upon scientific knowledge production, and the commotion that they create. Young scientists ought to understand the contradictions of the world that they inherit; and be prepared to move with, and react to, these forces. Crucially, a critical understanding of the narrative of the knowledge economy and the infringing tendencies of liquid modernity will bestow a sense of control in one's scientific life. In the next section, I reflect upon what we have learnt about young

³³ Acquiring research funding through well-written proposals that adhere to the policy language. This is not to imply the proposal is of less scientific value, but that its policy value, or value to the funder, is cleverly articulated.

scientists' constructions of scientific identity, before moving to answer the question of how well prepared they are for a scientific life led in the knowledge economy and liquid modernity.

7.3 Lessons learnt: young scientists' construction of identity

The data have shown us that young scientists' constructions of identity possess three striking characteristics, regardless of the particular identity they subscribe to.

7.3a The knowledge economy is a moral issue, and scientific identity is in part a matter of morals

The first characteristic is that for all young scientists, scientific identity is understood, at least in part, as a moral identity. For young scientists, the decision of what sort of scientist they wish to become is, in part, a moral decision.

The academic literature on identity fits well with this finding. Looking more specifically at academic identity, Mary Henkel's *Academic identities and policy change in higher education* (2000) remains the most authoritative analysis of identity in academic life. In her opening discussion, it is clear that Henkel expects moral values to play an important part in the formation and sustenance of academic identity, since philosophical musings tell us that morality is an inextricable part of identity, on both the personal and public level. Henkel enrolls the support of a number of philosophers in order to substantiate her point. Alasdair MacIntyre, she notes, reminds us of the importance of moral tradition; of a '*defining community*', that is premised upon a particular moral assessment of the world, in identity formation (MacIntyre, 1989, cited in Henkel, 2000: 15). Hans-Georg Gadamer and Charles Taylor, she observes, stress with even greater explicitness, the extent to which tradition and community are founded upon moral values. Thus, the frame of reference from which *all* identity constructions - including academic - are drawn, must be moral. As Taylor explained:

To know who you are is to be oriented in a moral space, a space in which questions arise about what is good or bad...what has meaning and importance to you and what is trivial and secondary.

(Taylor, 1989: 28, cited in Henkel: 15)

That young scientists view their scientific identity to be in part moral, and deem judgements on scientific knowledge production and careers to be in part moral matters, seems to fit seamlessly

with an established philosophical discourse. However, when we recall the image of the modern scientist, portrayed in chapter three (3.2d), we can see that in asserting the moral part of their scientific identity, young scientists confound many popular historic and contemporary beliefs about the scientist.

In chapter three, studies from the sociology of science revealed to us that scientists have long upheld their apolitical and amoral essence in order to secure their unique and influential position in society - particularly vis-a-vis private interests and the state (3.3). Today, Steven Pinker thinks that scientists are viewed with even less humanity than previously. In Steven Shapin's *The Scientific Life*, he is quoted with the following:

The old notion of the scientist as hero has been replaced by the idea of scientists as amoral nerds at best.

(Pinker, quoted in Shapin, 2008: xv)

According to Pinker, technical proficiency has triumphed as the hallmark of the scientific profession, meaning that we expect scientists to be merely '*amoral nerds*'. In this account, scientific expertise - a morally neutral form of knowledge - is all that matters; and the moral agency of the scientist is suppressed on the grounds of being non-relevant to scientific work. The image of science as a morally neutral institution is of course nothing new, as our consideration of the narrative of modernity revealed (3.2). Enlightenment ideals linger on today. As the science policy researcher Jack Stilgoe reflected, it is understood that '*scientists need to take themselves out of the equation; suppressing values in the quest for objectivity*' (Stilgoe, 2009a: 31). '*Suppressing values*', however, is something that young scientists find hard to do, particularly when presented with the relative newness of knowledge economy science.

In many ways, it is of course a fallacy to say that science has traditionally been value free - a point argued by the science studies scholars documented in chapter three. Even Robert K. Merton's CUDOS system - consistent with the Standard View - implied a commitment to modern, Enlightenment values. The work of Kuhn, Latour and Woolgar, and Knorr-Cetina elaborated upon Merton's image; science does indeed follow values, but they are internally constructed. The norm of '*disinterestedness*' is thus significant in the unique history of the scientific community; from a sociological point of view, it is the norm that has been classed as the root cause of its longstanding

power and authority. The disinterestedness of the scientific community has enabled it to hold up to the public the image of a morally-neutral community united by universal truths. What is so interesting therefore, in the case of the young scientists and the knowledge economy, is that consensus formation is completely lacking. The ‘disinterestedness’ of Merton’s model is now compromised, since young scientists fail to put on a united front towards the knowledge economy. Instead, we find five moral positions on the knowledge economy, and five sets of advocates eager to assert that ‘this’ is the proper account of science. Thus the data expose the notion of scientists as ‘*amoral nerds*’ to be a myth, and raises the question of whether the knowledge economy will threaten the disinterested and unified image of the scientific community.

Another way to think about young scientists’ constructions of their identity is that as well as being moral, they are very honestly ‘human’. Young scientists cast themselves somewhere between the ‘*hero*’ and the ‘*amoral nerd*’ of Pinker’s dichotomy; automatons they most certainly are not. The superiority of the ‘*hero*’ would not flatter them. As Daniel was keen to point out, scientists:

*...are people too, they have families... [but] to the public they are just freak scientists.
We have an image problem.*

(Daniel: 10)

Charlie agreed with this sentiment, disliking the label of ‘*public engagement*’, because, in his mind, it separated scientists and non-scientists on unjustifiable grounds of otherness (7). Contrary to the collective tendency of society to remember singular heroes - Newton, Darwin, Einstein – young scientists wished to convey the human *ordinariness* of their research lives. Further still, undermining the tendency of popular media accounts of scientists as aloof, misanthropic, or almost *Frankensteinesque* in their work; young scientists viewed scientific identity as inseparable from moral character.³⁴ Young scientists’ judgements on what they believed to be right or wrong stood at the heart of their scientific life.

The knowledge economy is a phenomenon that raises moral questions; it invokes a reaction about what is right or wrong, good or bad, in scientific life. Accordingly, knowledge economy stakeholders must recognise that young scientists are, at least in part, moral agents, affected by deep-rooted moral values on science. A knowledge economy narrative that consists largely of

³⁴ See Stilgoe, J. (2009b). ‘Why scientists need to get a life’; listed in the bibliography.

promises of economic growth and utilitarianism, as is presently the case, will therefore be limited in its moral appeal. It speaks primarily to the third-order capitalists, and its gravitational pull does not extend beyond the weak pragmatists, who offer up only a lukewarm acceptance. So while the third-order capitalists welcome this value-set with open arms, for others, the knowledge economy - when construed in the narrow terms of orthodox policy - becomes morally problematic.

Broadening the language and diversifying the vision of the policy narrative could transform the way in which the knowledge economy is perceived by young scientists. The knowledge economy does have more to offer than economic growth, impact and utilitarianism (Hancock et al., in Temple, 2011). It can foster multi-disciplinary work, enable an enhanced stake for non-scientists in scientific projects, and it places an emphasis on improving science communication, through a multitude of new platforms. Furthermore, it provides an ongoing justification for the massification of higher education, away from the elitist systems of the past. Paradoxically, knowledge economy stakeholders have displayed a depressing lack of inventiveness in its marketing. Young scientists are an assertive and diverse moral population. If the knowledge economy is not presented as an inclusively attractive prospect, the UK risks the loss of some of its brightest scientific talent and a wasted investment in human capital.

7.3b The persistence of modern habits

The second characteristic common to young scientists' constructions of identity is that their understandings of identity, morality and agency reflect the ideals of the paradigm of modernity. While we have established the point that the identity of young scientists are in part moral; we can say also that these identities fit the norms of modernity.

In chapters five and six, we saw how discipline, understandings of the nature and production of scientific knowledge, and desired career trajectories shape scientific identity and behaviour through the STEM PhD. Additionally, we saw that a reliance upon dichotomies heavily informs scientific identity construction. These dichotomies included: basic versus applied knowledge; academic versus industrial research; public sector and private sector. I have argued that these dichotomies are overturned by the knowledge economy and liquid modernity. So too are hopes for a single identity and a job for life. What we can say, then, is that young scientists' understandings of scientific knowledge, identity, morality and agency are not in keeping with the epistemological demands of the knowledge economy and liquid modernity. Rather, young scientists define the role of the

scientist, and the process of scientific knowledge creation, through concepts that accord with modernity.

In fitting with the project of modernity, young scientists conceive of scientific identity as being *solid* and *stable*. This identity rests upon understandings of virtuous science; but these understandings are identifiably modern too, since young scientists rely upon their scientific discipline, narrowly construed, to form these judgements. Disciplinary '*boundaries*' are understood to be so effectively fortified, as in the modern period, that young scientists use disciplinary norms to assess good and bad science (Gieryn, 1983). Young scientists' conceptions of morality and scientific identity thus correlate strongly to discipline, and are notable for their epistemic narrowness. While the precise dynamics of causality are untraceable in the data set - as is the case in most social research - it is suggested, in chapters five and six, that the scientific purists find the knowledge economy morally repugnant because it undermines the norms of their disciplinary homes: biology and medical research. This link is clear also in the socially-oriented young scientists, who originate from medical research and conservation. For the third-order capitalists and strong pragmatists, we see how studying for a PhD in an applied scientific discipline either presupposes or consolidates a moral position that welcomes the knowledge economy.

A moral judgement of right and wrong may lie at the heart of young scientists' scientific identity; yet it is a judgement that is bound by disciplinary-led, epistemic norms. Merton's emphasis upon *communalism* and *universalism*, and Kuhn's model of *normal science*; both of which were models constructed to describe science *before* the postmodern turn, appear to have lost little of their explanatory powers. For most of the time, young scientists appear to uphold the norms of modernity; reproducing the status quo that they encounter. They strive towards a scientific life that is premised upon disciplinary rules, a foretold epistemology, and career options that are constrained by a normative disciplinary framework. The prospect of overhauling one's inherited disciplinary norms, of challenging orthodox epistemological accounts, or of moving freely across the moral spectrum, is not something that young scientists seem willing to do.

Consciously or not, young scientists promulgate a modernist account of science and identity. They share modernity's ambition of creating solid and stable identities. They perpetuate modern descriptions of the world as a collection of systems separated by strict boundaries and differences. As with the rigidity of the five moral positions; the moral constitution tolerates little room for

exchange across, or the restructuring of, dichotomous boundaries. Central to the modern way of organising the world is the cult of ‘otherness’. Ergo, a fundamental part of one’s identity is ordained from distinguishing what one is *not*; and, the complementary belief that two antithetical explanations cannot simultaneously be truthful. Examples of the ‘*false boundaries*’ propagated by modernism are those stated to exist between the natural, social, and discursive; or, between science and the political (Kendall and Wickham: 100). For the modern scientist, the scientific method and disciplinary norms offered starting points from which epistemology, morality, agency and identity could be meaningfully developed, in compliance with the truthful natural order.

Contemporary young scientists continue to employ many of the principles of modernist thought as they construct and narrate their scientific identity. They aim towards an identity that is solid and stable; apparently believing that the achievement of such a fixed identity is the best means of preparation for their scientific career. Reflexive flexibility is not valued; on the contrary, young scientists do not believe that all five moral positions can sincerely co-exist. The scientific purists and third-order capitalists, uphold fiercely the rightfulness of their moral position; they believe that their understanding of normal science ought to be writ large. It follows that the notion of ‘otherness’ is critical in establishing each particular scientific identity, even if all that ‘otherness’ conduces is the disparaging of another viewpoint. We can think back to scientific purist Sophia’s incomprehension of how a fellow young scientist could move into ‘*private research*’ upon completion of their doctorate (6), or the equal denigration from third-order capitalist Will, who remarked that researchers who longed for a career within academic research only must be ‘*very selfish*’ (6). These statements reveal to us the importance of defining what one *isn’t* in the process of asserting what one *is*; and furthermore, of young scientists’ continued conceptual dependence upon the non-permeable boundaries that are imagined to exist between contemporary sites of scientific knowledge production.

7.3c Scientific identity is a search for coherence

As young scientists narrated their scientific identities, the third striking characteristic is the importance of coherence. It appeared that the modern stipulation of ‘*consensus formation*’ as a hallmark of normal science, had been internalised by young scientists as they deciphered the relationship between disparate elements of their scientific identity. This is why each particular moral position linked strongly to discipline, was shaped by scientific experience, and reinforced by

strategic behaviour. Young scientists were not comfortable with the idea of conflict between these distinct aspects of scientific life.

Young scientists expressed their position on the knowledge economy, research lives and scientific identity as a neat coherent whole. The emphasis that young scientists placed upon a coherent whole leads us once again to realise the importance they attached to constructing a solid and stable scientific identity. The emphasis upon coherence meant that in many ways, young scientists' narratives of their identity are notable for being constrained; it seems as though modernist habits of thought have dimmed the imaginations of young scientists. Towards the close of the interview, I asked young scientists about the personal qualities a successful contemporary STEM PhD researcher ought to possess.³⁵ Here, the nullifying effects of conceiving scientific identity as solid and stable, inflexible and fixed, are particularly evident. The consensus of young scientists was that the personality of the scientist had a role to play in their success. Yet when asked to elaborate upon what this personality might look like, the volunteered lexicon struggled to move beyond descriptions of hard work, productivity, obedience, and the achievement of predefined targets.

The message from young scientists was that *perseverance* - defined as the ability to continue with research regardless of continued set-backs - was the most significant identifier of a successful scientific personality. Interestingly, some of the interviewees suggested that the necessary perseverance was forged at the cost of the healthy personality. Strong pragmatist George, whose thoughts on the mental unhealthiness of academic life have already been documented, concluded that '*a slightly autistic geek*' would be most predisposed to scientific success (15). Third-order capitalist Graham agreed that perseverance was the most important characteristic for the successful completion of a doctorate; his dismay at this being cited as a reason why he wished to leave the academy post-PhD.

The only attributes so far I've discovered that PhDs require is tenacity. If you can just slog on you'll get there regardless of your abilities... I've seen people with enormous abilities do very badly and I've seen people with what I would have said were limited abilities do very well because the PhD isn't about producing amazing stuff it's about proving that you can produce something.

(Graham: 10)

³⁵ See appendix four, question 19.

The paradoxical tendency for young scientists to besmirch the qualities thought to underpin success in academic life was found elsewhere in the interviews. Strong pragmatist Daniel compared the perseverance needed in scientific research to '*a masochistic tendency to be able to... come back for more punishment*' (13). Such comments did not just emerge from strong pragmatists or third-order capitalists; that is to say young scientists for whom leaving the academy after the doctorate seemed likely. Socially-oriented Sophia, determined to stay within university science, joked that an individual needed '*to be mad*' (11) to strive for this career. Mixed feelings aside, the message was unanimous; becoming a successful scientist implied hard-work and proven results.

It is noteworthy that in the minds of the young scientists, these characteristics amount to a description of *personality*. It seemed as though young scientists had reflected little on the impact of personality in scientific life. The separation of self and science is, of course, another very modern tendency. Certainly, there seemed to be a confusion of process and product. Rosie typified this error. Having told me that personality mattered in scientific success, she went on to justify her answer by explaining '*if they [the scientist] produce the goods, that's all that matters*' (12). If published truths are '*all that matters*', then, as per the modern paradigm, there can be no rightful place for the personal in science. While I do not wish to deny the importance of hard work and tenacity for achieving scientific success; young scientists' limited conceptions of 'personality' are nonetheless striking. In their descriptions, young scientists were not really talking about personality at all. It is not too extreme to suggest that the capacities listed by young scientists equally describe a competent and productive robot. To further highlight the limit of this vision, we can look to the inexorably human qualities omitted from young scientists' accounts. Nothing was said of ethical awareness, empathy, intuition, reflexivity, or the contingency of human knowledge.

In this section I have argued that young scientists constructions of their identity are in part moral, but constrained by a dependence upon the modern paradigm. This is not to say that young scientists are consciously aware of the paradigm of modernity. It is more likely that they acquire ideas about science and scientific identity from their immediate research environment: their department and the university. In the next, and final, section of this chapter, I look at the current narrative of scientific identity promoted by UK universities, and I find there is a strong correlation between this and those of young scientists.

7.4 Looking to the future: two types of scientific identity for the knowledge economy

It has become clear through this thesis that the STEM PhD acts as a space and time in which young scientists grapple with questions of scientific identity and scientific life. In the case of the weak and strong pragmatists, the exact end-point of this scientific identity is not yet worked out in the way of the scientific purists, socially-oriented or third-order capitalist; but the theme of aiming towards a single, successful scientific career is constant - the only difference is that the weak and strong pragmatists possess a flexible attitude, in varying degrees, towards their particular scientific identity. Their current indecision is not one that they wish to continue; rather it is presently tolerated until a definite decision upon the single most lucrative career path can be made.

Putting aside the diverse vocational plans of young scientists, it is clear that the STEM PhD continues to be understood as a preparation for a scientific career; however broadly this is construed. Another way of thinking about this is to suggest that the STEM PhD is a time for *scientific individuation*. Individuation is a concept with links to several areas of scholarship - namely psychology, philosophy and sociology. It can be understood as the process of a person becoming their 'true' self; of forming a stable personal or professional identity. Scholars have long contested the process of individuation, and indeed, when to demarcate the process's end. It should not be assumed that the formation of a stable identity is necessarily akin to the modern definition of identity: Carl Jung's theory of individuation, for example, proposed that a stable identity could be achieved only through the recognition of the diverse, possibly conflicting, parts of one's life and personality (Stevens, 1994: 38-42).

Individuation is concerned with the creation of an identity that can flourish amidst a given context. In this section, I am concerned with *scientific individuation* in the context of the knowledge economy and liquid modernity. I will argue that currently, UK universities and policy makers promote *one type* of scientific individuation, leading to the modern type of scientific identity upheld by the young scientists. I then propose a second, alternative version of scientific individuation, aimed at the construction of a liquid scientific identity. As we saw in the policy literature covered in chapter two, and the observations of young scientists in chapter five; the university is now a key institution of the knowledge economy. University science has changed because of it. My argument is that, accordingly, young scientists' understandings and constructions of scientific identity need to change also; whether they intend to forge a career in university science or elsewhere in the knowledge economy.

The main points of difference between these two scientific identity types are outlined in table 7.1 overleaf. The modern scientific identity is presently encouraged in UK higher education policy, which, in promoting specific narratives about knowledge, expertise and skills, directs young scientists towards a solid and stable scientific identity. In the contrasting column we have the hallmarks of the liquid scientific identity. In the two part discussion that follows, the process of individuation that underpins each identity type is discussed and critically assessed.

| <i>Modern scientific identity</i> | <i>Liquid scientific identity</i> |
|--|---|
| The contemporary scientist must contribute towards the knowledge economy | The contemporary scientist must understand the possibilities, complexities and contradictions of the knowledge economy and broader epistemic changes in the liquid modern landscape |
| Modernity and progress inform scientific identity | Liquid Modernity and reflexivity inform scientific identity |
| The contemporary scientist must possess technical expertise | Technical expertise must be met with cultural and epistemic awareness |
| The scientist must focus upon analysis and precision | The scientist must be prepared for complexity and disruption |
| Scientific value is demonstrated through the impact criteria imposed by performativity | Scientific value cannot be fully captured by the performative criteria: ephemeral and non-tangible aspects of scientific knowledge are essential in the development of scientific understanding |
| Transferable skills education complete science training and the possession of these skills can be measured in performative attribute lists | Reflexive practice, liminal spaces for interdisciplinary discussion, and work placements across various sites of contemporary scientific knowledge production complete scientific training |
| The scientific career trajectory is vertical and linear | The scientist must be prepared for vocational movement, some of which may be horizontal; across different sites of scientific knowledge production |
| Knowledge is hierarchically structured | Knowledge is heterogeneous and anarchic |
| Scientific identity should promote the interests of the scientific community | Scientific identity formation must incorporate an understanding of knowledges and values beyond the scientific community: sociological, political, economic, epistemological, and moral |

Table 7.1 Two types of scientific identity

7.5 Type one: Modern scientific identity for the knowledge economy

In the present STEM PhD, *scientific individuation* is approached by UK universities in a thoroughly modern way. The ideal of constructing a solid and stable scientific identity is upheld; and the method employed to achieve this end follows the modern pattern: it is ordered, measured, calculable and rule-governed (Barnett, 1999: 21). Indeed, the only indication that the postmodern turn occurred, is that UK universities attempt to demonstrate that they are producing scientists fit for the knowledge economy by adhering to performative criteria.

Two assumptions anchor the process of scientific individuation followed by UK universities. The first is an assumption of *what*: it states that scientists ought to contribute to the knowledge economy. The second is an assumption of *how*: it states that this contribution is measurable and ought to be demonstrated against performative criteria. These two assumptions result in a *why*: which restates that the contemporary scientists must contribute to the knowledge economy; and that the litmus test to measure this contribution is one's performance against the performative criteria. I will now explore these two assumptions, and their consequence, in more detail, before assessing them in reference to the *structure-agency* dualism of sociological theory (7.5d) and adding a note on the longevity of the modern project of identity (7.5e).

7.5a Scientists ought to contribute the knowledge economy

UK universities approach scientific individuation through the STEM PhD in a manner consistent to the modern project of identity; however, it is evident that some tweaking has ensued in light of the knowledge economy. Modern principles continue to litter the rhetoric of the contemporary university, but there is space for the knowledge economy also. As young scientists work towards the completion of their doctorates, they are socialised as members of their university's international '*community*'; a community predicated upon a modern mission statement of universal excellence, discovery, innovation and progress (2012). Two of Merton's norms in particular - *communalism* and *universalism* - endure as institutional imperatives of the science-focused university.

In addition to the modern rubric of universal excellence and scientific progress, there exist the expectations of the knowledge economy. Thus, we see employability as a more recent aspect of scientific individuation. The strategy to enhance young scientists' employability in the knowledge economy was cemented at the national policy level with the 2002 Roberts Review; and UK universities have dutifully translated its recommendations into local practice. Transferable skills

training and the knowledge economy employability agenda are transparent items on the agendas of UK universities. As the host institution of our young scientists, admits:

Preparation for the workplace is increasingly recognised as an important part of a university education, and the importance of producing graduates who are well-rounded and highly employable is integral to the [university's] mission.

(2011)

This quote indicates how employability for the knowledge economy is now considered central to scientific training and the development of scientific identity; and also, it reveals the extent to which the capitalist rhetoric of the policy narrative of the knowledge economy has permeated the vocabularies of UK universities. Scientific individuation is approached in reference to the knowledge economy, and it is conceived as an economic process in itself; at the end of which the ‘scientist as commodity’ is produced.

7.5b Scientific contribution is measurable

From the perspective of UK universities and successive governments therefore, the objective of scientific individuation at the time of the STEM PhD is to produce a scientist who will contribute to the UK knowledge economy. As we have already discussed, in reality, young scientists stand divided in terms of their willingness to work within, and thus contribute to, the knowledge economy. For the moment however we will cast aside judgements of how well the approach of UK universities is working to prepare young scientists for a scientific life in the knowledge economy; and focus instead on the methods that UK universities use.

A particular type of ‘method’ is employed by UK universities as they attempt to control the individuation process. This method encapsulates both the modern tendency of precise measurement and the postmodern performative call for the demonstration of competency.

The fundamental educational attributes to which we aspire are the same in all our disciplines. They should define the way our graduates approach problems...

(2011)

Attribute lists have proliferated, indicating the knowledge and skills that the successful, knowledge economy ready scientist ought to possess. Yet, within this approach lies a tension: while contemporary attribute lists demand more than that expected of the modern scientist - good communication; the ability to network; an appreciation of cost and value being just a few examples - they still amount to a totalising vision. In keeping with the modern constitution, attribute lists neatly define the identity of the contemporary scientist, albeit with the measured inclusion of skills deemed necessary for the knowledge economy.

Attribute lists aspire to a modern end - a solid and stable identity, by using a postmodern means - a performative methodology. They respond to the policy narrative of the knowledge economy by suggesting that employing a STEM PhD graduate makes for a sound investment; and that crucially, the knowledge economy employer knows in detail what he or she is paying for. The tick-box approach of this performative approach to scientific identity brings to mind Valerie Janesick's description of *'methodolatry'* in the social sciences (2000). Janesick feared the rationalising consequences of the postmodern turn for the social sciences, and along with other interested commentators, lamented the rising dominance of quantitative methods.³⁶ According to Janesick, this dominance was explainable by a crisis of confidence gripping social researchers, who longed for their discipline to follow and subsequently rival the physical and natural sciences. For Janesick, this led to an *'almost constant obsession with the trinity of validity, reliability and generalisability'* (Janesick in Denzin and Lincoln: 390). At the heart of the privileging of quantitative methods is a preoccupation with risk-management; namely, the belief that risk can be calculated and monitored within a framework of performative criteria.

Methodolatry has come to dominate the management of UK higher education; evident in the Research Assessment Exercise (RAE) and the Research Excellence Framework (REF) assessments of research quality, and the attribute lists at the individual level. Looking specifically at the issue of researcher development, Vitae's *Researcher Development Framework* (RDF), supported by RCUK and Hefce (Higher Education Funding Council For England), uses an attributes-measurement model in order to track individuation from early stage PhD student to established academic researcher. Researchers, and those responsible for their development, are guided through tiers of expected attributes - known as *'descriptors'* (Vitae, 2011: 2). The descriptors are broader in scope than a

³⁶ For a more recent expression of this stance, see the article *'Physics Envy'* by Kevin A. Clarke and David M. Primo, published in the *New York Times*, 30th March 2012, which summarises the thesis of their book: (2012) *A Model Discipline: Political Science and the Logic of Representations* (New York: Oxford University Press).

traditional academic job description: income generation and enterprise activities are measured; and self-reflection and responsiveness to change are included. The RDF asserts its suitability for both public and private sectors, and its *raison d'être* is bound to the policy narrative of the knowledge economy:

To build the UK workforce, develop world class researchers and build our research base.

(Vitae, 2011: 1)

Despite the proclaimed combination of breadth and propitiousness, the effect of the RDF is emphatically not the development of a liquid identity. As a tool it is rigid; it asks for demonstration of each descriptor at every stage, and, in assuming that the RDF comprehensively captures the traits of the successful researcher in the knowledge economy, it therein presents us with a fixed vision of what being a researcher means. Thus, the method is modern, and the result is still modern; albeit with a slight adjustment in order to display servitude to the knowledge economy. I believe that the shortcomings of this approach will soon be recognised, precisely because it oversimplifies the complexity and contradictions inherent in the knowledge economy.

The pressures of methodolatry, and the financial incentives attached to it, weigh down upon university departments, supervisors and young scientists; at each level, performance is called for. Rather than embracing the complexity and uncertainty of the knowledge economy, or the multiple frames of reference thrown up by liquid modernity; a low risk approach to scientific individuation is favoured. It is thought, in a naïve and modern fashion, that the formation of a successful scientific identity can be controlled for by working through the requisite boxes of the attribute list. At the national level, policy makers are confident that the production of x number of young scientists with a STEM PhD will ensure that the demand for knowledge economy workers is met.

The data reported in this thesis reveals that this is a simplistic and incorrect forecast; critically, the moral positions of young scientists are not taken into account. Many young scientists are adamant that while they may possess the attributes to work in the knowledge economy, they will turn their back on it for reasons of value. The performative space of scientific individuation has no room for the *moral nerd*, and this oversight may leave knowledge economy policy makers and stakeholders

disappointed when they assess the number of willing knowledge economy workers that the STEM PhD produces.

Janesick would no doubt foresee the disconnect between reality and expectation, since she views methodolatry as a reductive and dishonest means of portraying academic life. As she explains:

Experience is separated from knowing....[and]...is another way to move away from the actual experience.

(Janesick, in Denzin and Lincoln: 390)

The performative approach to scientific individuation leaves us with a sanitised and unrealistic view of university life, and of the STEM PhD experience. It is a methodological approach designed to serve the supply and demand of the knowledge economy, but by eclipsing the value questions of scientific knowledge production and scientific identity, it fails both in this regard and also in illuminating to young scientists the true nature of the knowledge economy, liquid modernity and of a scientific career traversed across these complex terrains.

7.5c Performance is success

Performative logic would stipulate that, moral wishes aside, if a young scientist meets the requirements of the attribute list, then they will be prepared to flourish in the knowledge economy. Furthermore, if the allocation of financial resources for science continues to be determined by performative displays, then the most rational professional behaviour a young scientist could enact is to follow the performative rules. The question that we must answer is this: will those young scientists who perform well *within* the current training structure set by knowledge economy policy, be best equipped to forge the most successful scientific careers within it?

The tentative answer appears to be no. In chapter two, we discussed how the policy narrative of the knowledge economy simplifies and homogenises the idea of the knowledge economy. As a result, its notion of training for the knowledge economy is impoverished, and young scientists are bestowed with a simplified understanding of it. Young scientists demonstrate an unsophisticated grasp of the complexities and possibilities of the knowledge economy; and furthermore, display an ignorance of liquid modernity. We can think of the scientific purists who juxtapose the disinterested nature of university science with interested, knowledge economy science, and continue to think of

the university as a detached ivory tower. Equally biased are the third-order capitalists, who may seem well placed to take advantage of the knowledge economy, but demonstrate a disconcerting lack of understanding of the importance of basic research, and of the mutually beneficial relationship between university and industry that a knowledge economy ought to foster.

Far from preparing young scientists for the knowledge economy, the effect of the contemporary STEM PhD seems to be that young scientists are left unable to handle the dissolution of old binaries, and believe instead that the divisions between university, economy, and society very much still exist. The rigidity of the performative attributes approach appears to have implied to young scientists that the knowledge economy provides a more complex ecosystem than previous in which to practice science; and that the task for the contemporary scientist is to find the most morally palatable space within this melee. A scientific life that spans all sites of scientific knowledge production in the knowledge economy is not imagined. As we have seen, some young scientists continue to think that the knowledge economy represents bad science, and is somehow, avoidable for them. If the university is interested in scientific individuation only insofar as it means preparing scientists for the knowledge economy, then surely - as we think of the defiant and extreme positions on the moral spectrum - our conclusion must be that it could do better.

The knowledge economy and liquid modernity demand a liquid, flexible scientific identity that transcend the structures of modern science. A dependency upon difference and otherness, as is the case with the five moral positions, indicates that young scientists' constructions of scientific identity are lacking in this critical regard. Theirs is an identity premised upon binaries and otherness; and Henkel warns us that this model of identity can only be successful when there is a like-minded community for that individual to join (Henkel: 14). This is the story of MacIntyre's historically-attuned individual; wherein one's ability to carve up the present world depends upon a strong sense of inherited kinship (MacIntyre, in Henkel: 14). Charles Taylor also advocated the importance of a '*defining community*' in the consolidation of identity (Taylor, in Henkel: 15). Yet these models of identity can no longer offer a guiding light when the scientific community of old is being revised; the academic community of practice is far harder to enter, and the future implies liquid cosmopolitanism - a scientific identity that belongs to a constellation of disparate communities. For this reason I remain unconvinced that Doctoral Training Centres (DTCs) offer an improved training model for students of the STEM PhD. DTCs offer only a very limited taste of interdisciplinary working, and do little to open the eyes of young scientists to the knowledge economy and the

epistemic chaos of liquid modernity. Perhaps more serious however, is the valid question to be asked of the rationale behind cultivating a sense of community through the STEM doctorate, when, upon completion, the majority of young scientists will find that their sense of belonging to the university community must be disavowed.

If at present universities are most concerned with preparing young scientists for the knowledge economy then it seems, as Barnett has argued, that they need to respond to the changing notions of scientific identity and the scientific profession in the knowledge economy and liquid modernity. I share Barnett's critical appraisal, arguing that universities have '*largely adopted a semi-detached response*' in relation to changed understandings of knowledge and science (Barnett, in Temple: 217). The vice of the university, and the scientific community more broadly, has been to brush aside the practical and epistemic changes brought on by the knowledge economy and liquid modernity. Therefore, we see STEM PhD students who may be better accustomed to the performative rules of the knowledge economy, but, more importantly, continue to cling to a notion of scientific identity that, being fixed and absolute, indicates only a superficial understanding of the epistemological, political, economic and social contexts that ground present day science.

7.5d A triumph of structure

The structure-agency dualism of sociological theory provides a further way to think about the individuation process during the STEM PhD. In sociological terms, we can say that the current approach to scientific individuation gives primacy to *structure* - that of the knowledge economy - over *agency*. The agent in our scenario is the STEM PhD student; the young scientist whose scientific identity is shaped by a pressure to meet the performative methodolatry that encroaches upon their research life. The prioritisation of structure in this context restricts young scientists' causal capability to formulate their scientific identity.

While it is clear that young scientists *believe* that they have agency over their scientific identity and career, the type of scientific individuation employed by UK universities is in fact designed to serve the knowledge economy, and leaves little room for the fulfillment of the moral aspect and liquid potential of young scientists' identities. As an aside, it is clear also that this narrative imposes an inaccurate account of the knowledge economy and contributes to the unsophisticated reactions of young scientists to it. Margaret Archer classifies such an analysis as '*downwards conflation*', meaning that the explanation of a social dynamic grants causal efficacy to the structure while

ignoring the agent (Archer, 2000: 5). Where possible, Archer warns against such an analysis, for it is likely to be reductive. However in this instance, the policy narrative of the knowledge economy and performativity do appear to have been granted didactic powers in determining how UK universities approach scientific individuation; and thus, we can only conclude that the agency of young scientists is depressed as a result.

7.5e The longevity of the modern project

I have argued that the current approach to scientific individuation inhibits young scientists' preparation for, and understanding of, the knowledge economy, at the time of STEM PhD. If this is so, we may ask how we have ended up in such a situation. One explanation is that policy about transferable skills and scientific careers tends to be informed by senior scientists. It is the successful and the senior who are called upon for consultation with policy-makers; it is assumed that the concerns of young scientists will be reported through this mechanism. The problem is that in the era of the knowledge economy and liquid modernity, senior scientists' reflections on *becoming* and *being* are likely to be out of date. As a result, young scientists are at risk of becoming, if they are not already, a marginalised and dispossessed group. As I move to the second account of individuation, I endeavour to address this imbalance and offer a vision that better enables and empowers young scientists as they prepare for the knowledge economy.

7.6 Type two: Liquid scientific identity for the knowledge economy

I will now offer an alternative tale of scientific individuation, and I must begin by saying that this discussion will follow a slightly different form to the previous section. This is because, far from aspiring to produce a similarly bounded attribute list, the type of individuation that I wish to promote is characterised by fluidity and fuzziness. It responds honestly to three realities that encompass young scientists: the highly *individual* journey of the STEM PhD; the *serendipity* of scientific inquiry; and finally, the uncertain and *fractured future* of the knowledge economy and liquid modernity. To restate, I envisage these reforms as developing and building from the Roberts' transferable skills agenda, and I do not wish to undermine the value that these practices have had in promoting young scientists' awareness of their versatile potential, as many of the interviewees testified.

Drawing once again from Barnett's writings, we can think of this second type of individuation as putting forward the case for young scientists to assume a greater responsibility for the *'part-*

authorship’ of their epistemic experience (Barnett, in Temple: 216). Before I argue the case for a liquid scientific identity, I should first address the obvious criticism that the vagueness of what I propose is tantamount to pedagogic insipidness. In response to this, I suggest that for the moment we broaden our perspective to consider the purpose of a university education. If we look at scientific identity type one, we would assume that the value of higher education is to produce the highly skilled employee, who possesses excellent technical knowledge acquired through their university studies, and will contribute to the knowledge economy. Many involved in higher education policy making would no doubt be entirely satisfied with this answer, and it would certainly seem sufficient when tallied up against the policy narrative of the knowledge economy. It is a view that leaders of science-focused research-intensive UK universities have accepted. The priorities listed by one such former leader are typical: that universities have a responsibility to develop excellent scientists - defined by their technical expertise - and that the prosperity of the UK economy will follow from the delivery of the next generation of scientists. Understanding the wider context of science is not part of the picture:

*[On]... whether we should be educating the future citizen or the future scientist...
emphasis on the former is damaging our development of the latter.*

(Sykes, R. in Perks, 2006: 36)

If we amble down this path of thought however, it is not long before we face the question of how a university education differs from vocational training; a question that Stefan Collini recently answered with some very compelling distinctions. In *What are universities for?* Collini discusses the ‘*animating*’ principle of the university (Collini, 2012: 57). He is concerned to distinguish the university from all other institutions in which learning takes place. The difference, for Collini - and, incidentally, for Humboldt, Jaspers and Newman, as we learnt in chapter three - is the breadth of perspective that a university education instills in the learner. Collini refers to this as the ‘*contentlessness*’ of higher education, and regards it as its most valuable characteristic (Ibid.: 45). The ‘*contentlessness*’ of a university education implies open-ended inquiry that accepts no prescribed end-point; it embraces the ungovernable nature of knowledge; and fundamentally, it marks the individual recipient out as being averse to one-sidedness and bias. Collini likens these qualities to what:

Philosophers might call second-order...freedom, equitableness, calmness, moderation and wisdom.

(Collini, 2012: 45)

If we reflect upon the regimented moral positions and identity types of the young scientists, it would seem that they fail to live up to this image of sophistication. The partiality and narrow-mindedness of their constructions of scientific identity is undeniable. From Collini, we can conclude that the '*contentlessness*' value of higher education is not something that young scientists embody; it seems that they have not properly understood the axiomatic, animating principle of the university. This should concern not just the individual young scientists, but the university itself, for some of these young scientists will be entrusted with its future development.

7.6a Performativity does not capture all

It appears then, that young scientists are failing to meet even the traditional expectations of what a university education ought to confer. The limitations of the approach to scientific individuation advocated in current higher education policy become clearer still when we consider in turn the individual journeys of the STEM doctorate.

Let us begin with the narratives of individuals. It is clear that there is no one account of what it is to do a STEM PhD; and acknowledging this generates yet another question of why the attribute ideal has been selected as a fitting model to guide researcher development. Young scientists portrayed their scientific lives with firm and neat narratives; metaphors of *fluidity*, *movement*, or *liquidity* were missing. Commensurate with the rhetoric of excellence and competitiveness purveyed by the scientific community, young scientists believed that the most sensible route to scientific success entailed a whole and express commitment to one career objective, as the game theory informed analysis of chapter five affirmed. Rarely in their doctorates are they encouraged to open their blinkered eyes, or derail from their narrowly defined trajectories.³⁷ Indeed, the weak and strong pragmatists, who cautiously consider the benefits of a liquid scientific identity, did so at the cost of great personal turmoil and a fear of professional rejection from orthodox scientific life. Moreover, it is a identity that they have forged alone; typically, they reach their pragmatism through disillusionment with their department and the university, which continues to promote the myth of

³⁷ Careers advisory services, available in most UK universities, do, in many cases, aim to make doctoral students aware of the vocational possibilities for them outside academia. Nevertheless, making use of these services is an entirely voluntary decision for the student.

inclusion and progress. Pragmatism may be favoured as they venture out to forge their post-PhD careers, but at the time of the doctorate, it is not a position that generates comfort. It is devised alone, without support; often after a year of existential angst and the abandonment of deep-rooted aspirations. Worse still, universities and higher education policy add to the impression that uncertainty is an unconventional, problematic mindset; certainly, it stands in contrast to the portrait of the confident, profit-maximising, careerist graduate identified in the Browne Review. Admitting uncertainty, or changing one's mind is a behaviour that young scientists remain reluctant to do; the hailed precision of the scientific method, together with the narrowness of the policy narrative of the knowledge economy, appears to have infiltrated their thinking on identity, agency and morality.

The problem with the narratives of the third-order capitalists, socially-oriented and scientific purists is that they are founded upon an outdated view of scientific knowledge production, and these individuals are unlikely to sustain their desired solid and stable, *modern*, identities. Their narratives run the risk of limiting career options and, harbingering existential crises later in their scientific careers, when their imagined future vocational selves fail to materialise.³⁸ The scientific purists, for example, need to appreciate the local politics of grant-writing and the socially-oriented young scientists will one day have to re-assess their principle that social and economic goods are mutually exclusive; an interesting false dichotomy to preserve, since the present day university confounds it.

Thinking of one's identity as *liquid* does not imply a complete abandonment of the moral values that young scientists hold to be essential to their sense of scientific self. However, it does stretch ways of thinking about identity, and raises the possibility of revising and recasting values in a way commensurate with the changing demands of one's environment. In encouraging young scientists to be flexible and less fearful of change, a liquid identity better prepares young scientists for the challenges of the knowledge economy and liquid modernity, and, on a more direct and practical level, it opens up the range of professional options that can be counted as acceptable.

The liquid metaphor would secondly be helpful for young scientists as they encounter the serendipity of scientific life. In the interview narratives, young scientists suggested ignorance of uncertainty and disruption in their scientific lives; believing that when problems were encountered, perseverance and hard work would ultimately furnish a solution. If this was not the case, as in

³⁸ The plight of scientific researchers who are not offered tenure, and feel that they have to switch careers after their second or third postdoc, is a foremost concern of the *Science is Vital* campaign (2011).

Olivia's experience, it was assumed that one's scientific endeavours had failed (4). This theme is noted in Delamont and Atkinson 2001 paper, discussed in chapter five. Delamont and Atkinson argue that young scientists are ill-prepared for the tribulations of the failed experiments that no doubt await them because experimental failure is edited out of scientific texts, thereby presenting undergraduate students with an unrealistic view of science (Delamont and Atkinson, 2001: 91). Consequently, when experienced first hand, the *'reality-shock'* of science is most commonly thought of as a personal failure, a reaction that is probably exacerbated by the fact that, as serendipity dictates, some students will encounter no or few problems (Ibid.: 89). Furthermore, when young scientists write up their thesis, they too edit out the failure. Thus it is easy to see why experimental failure and personal failure become confused in the minds of young scientists.

In reality, failure, serendipity and the rejection of theory, are hallmarks of scientific life, and they are by no means the indication of a poor scientist. In fact, philosophy of science scholars by no means agree unanimously with Kuhn's idea that consensus formation is the mark of normal science. As Martin and Sugarman report, the Austrian philosopher of science Paul Feyerabend (1974), and more recently Shulman (1986) find many followers in their rejection of Kuhn's paradigm revolution account of scientific progress (Martin and Sugarman, 1993: 19). Shulman is quoted to say that *'the coexistence of competing schools of thought is a natural and mature state'*, and not, a sign of *'paradigmatic retardation'* (Ibid.: 19). Additionally, we can recall Mitroff's 1974 study of the Apollo Moon scientists from chapter three of the literature review, to add weight to the notion that sociological ambivalence - and the cognitive dissonance to which it gives rise - are, *and always have been*, characteristics of scientific life. Thus, even if we put aside all concern for the knowledge economy - competing knowledge claims, and the subsequent uncertainty that follows, form a reality that young scientists ought to be prepared for. In other words, conflict within science is a norm that young scientists will have to contend with; and this disarray exists in addition to the multiple, competing frames of reference that exist to inform their scientific identity and position in the world. A liquid scientific identity encourages young scientists towards reflexivity and flexibility; and in doing so, it will make them better prepared for the routine upheavals of scientific life and professional life construed more broadly. With a greater understanding of scientific knowledge production, will come a greater sense of control; and hence, a more astute and productive scientist in the making.

Third and finally, it is proposed that the liquid identity is essential in order to successfully navigate the epistemic complexity of the knowledge economy and liquid modernity. The below quote, from Zygmunt Bauman, could not stand in starker contrast to the version of individuation promoted by the young scientists' host university, with its accent upon observable employability and a definable end-point of becoming. With Bauman, we see that in liquid modernity, individuation is a process that lacks an arbitrary stopping point; nor is it easily prescribed in reference to general principles.

The postmodern problem of identity is primarily how to avoid fixation and keep the options open.

(Bauman, 1995: 20)

A liquid scientific identity is precisely about avoiding fixation and keeping the options open. I will now outline three reforms conceived to encourage young scientists to construct a liquid identity, thereby allowing them to flourish amid the knowledge economy and liquid modernity.

Policy makers and employers ought to take note of the importance of the liquid identity model; because delivering the generation of scientist-entrepreneurs that they desire - able to move with competence and ease across the changing epistemic landscape - demands the promotion of a liquid scientific identity.

7.6b Reform proposal one: liminal spaces

The first move to encourage young scientists to construct a liquid scientific identity is the creation of *liminal spaces* within the structure of the STEM PhD. Liminality is a metaphysical concept, referring to the position of an individual at the threshold between two different existential states. It is thus ideally suited to a time in which identity is revised and constructed anew; when former values are re-assessed and carried forward with newer ideas prompted by the emergence of a different existential state. If the STEM doctorate is portrayed to young scientists as a time in which old ideas and values might be recycled, revised, or abandoned; then it is likely they will take the first step towards thinking about scientific identity as something that is subject to regular critical analysis and evolution. Moreover, it will be a first step in dispelling the myth that reflection, ambivalence and changing one's mind have no place in scientific life. The concept of liminality will provoke young scientists into confronting the uncertainty of their passage, and they ought, as a result, to explore many more identities and vocational options than is presently the case.

The existence of liminal spaces within the STEM PhD is further necessary because the personal story of individuation is edited out of the written thesis. Liminal spaces will allow young scientists to discuss with one another: the disconnect between expectation and reality; changing one's mind; and the experience of failure. This is an opportunity that they are currently deprived of. The interviews conducted in this project provide persuasive evidence for the need for a liminal discussion space; since it was clear that the young scientists greatly valued the occasion, a unique occurrence in their PhD. Certainly, young scientists did not suggest that this discussion of the social, political and economic context of science, and of scientific identity, was in some way irrelevant to their situation.

The relationship between science, state, society and the economy would form a likely framework for discussion topics; calling to question the dichotomy ventured by Sir Richard Sykes, between 'citizen' and 'scientist' (Sykes, in Perks, 2006: 36). The current orthodoxy of scientific individuation favours 'the scientist' at the expense of 'the citizen'. The message of the liminal space is that, far from following in the failed footsteps of polarising the *'two cultures'*; the scientist can prosper from both perspectives.³⁹ The knowledge economy and liquid modernity overhaul prior systems of meaning-making; and so the project of identity becomes more complex. The liquid pedagogy conflates the once distinct identities of scientist and citizen. This means also that the modern idea that *'only scientists are qualified to speak about and for science'* must be challenged (Wilsdon, cited in Henderson, 2012: 40). Consequently, the liminal spaces of discussion ought ideally to be opened up to non-scientific voices also. The perspectives of sociologists, philosophers, historians, political scientists and economists would enrich young scientists' understanding immeasurably and add a further sense of cosmopolitan coherence to the formation of a liquid identity. Another discussion, inspired by the findings of this thesis, could reflect upon the contemporary dominance of publications as a means to assess scientific knowledge, and subsequently influence the career success of individual scientists. The third-order capitalists object deeply to the attention awarded to publications; the liminal space would allow them to present their argument and debate with, for example, the scientific purists, who hold the contrary view that peer-reviewed publications remain the best way to validate the quality of scientific research.

³⁹ As per C.P Snow's infamous 1959 Rede Lecture.

7.6c Reform proposal two: reflexivity

The seminal theorists of late modernity would argue that the practice of carving liminal spaces into everyday life is essential for the successfully functioning individual, regardless of their profession. At the individual level, such liminal contemplation is better known as *reflexivity*. Anthony Giddens tells us that individuation is a project that lasts a lifetime; it entails the management of a coherent and yet perpetually revised identity, which is well-placed to flourish in a variety of ever-changing contexts and frameworks of understanding (Giddens, 1991: 5). In order to manage the life-long process of individuation, individuals must become *reflexive*.

For Giddens, along with Bauman and Ulrich Beck, the moral positions professed by young scientists would be recognised as short-lived expressions of scientific identity, because of the lack of reflection that they imply. If a young scientist did attempt to cling intransigently to a single moral position throughout the course of their scientific life, the proponents of the reflexivity thesis would expect that, in time, the individual would lose *all* sense of control amidst constant and overwhelming change. It is thus argued that young scientists must practice reflection in order to move with the times.

While the modern scientist avoided bringing excessive personal introspection into their professional activities, that personal values have become central to scientific life is the persuasive thesis of Steven Shapin's (2008) work *The Scientific Life*. For Shapin, the technical and moral cannot be separated. Shapin's scientist is proficient at expressing personal values, and assessing changing scientific knowledge production with their moral compass in mind. Shapin fears that the anarchy of liquid modernity, together with the relentless capitalism spearheaded by the knowledge economy, places the contemporary scientist in danger of an existential crisis, unable to function optimally. It is a crisis of the sort that Giddens warns us will continually plague the individual who does not reflect. Shapin too is convinced that a personal sense of control, attained through reflection, is a must when stability cannot be found in the outside world.

People matter; their personal constitutions matter; their virtues matter. And the reason they matter has to do with the radical uncertainty of these future-making practices.

(Shapin, 2008: 303)

We know already that *'virtues'* matter to young scientists, and so the construction of a reflexive, liquid identity would provide a means for young scientists to engage with the complex realities of contemporary scientific knowledge production and yet continue to reflect upon the moral values that they wish to protect. The recognition and protection of scientists' values is important. Indeed, in the time of the knowledge economy, the personal values of scientists may provide the one reservoir, from which the scientific community can draw in order to substantiate its claim to authority and power in society. Without this, contemporary scientists risk being perceived as mere automatons for capitalism; and with the notion of 'universal truths' confined to the modern period, the integrity of science could be lost. It is Shapin's view that the contemporary scientist must possess a finely developed sense of self beyond that of the amoral nerd.

Scholars of pedagogy consider the management of one's values to be a key part of successful learning and knowledge creation. Denise Batchelor uses her expertise in the philosophical conception of *'student voice'* to propose a typology that exposes the complexity of the contemporary learner (Batchelor, 2006). She describes student voice as comprising of three interrelated aspects: a voice for knowing; a voice for doing; and, a voice for being and becoming. The current model of the STEM PhD caters assiduously for the development of the voices of knowing and doing. As our examination of the scientific identity type encouraged by UK higher education policy and universities revealed, technical expertise - knowing - and methodological competence - doing - are attentively assessed and demonstrated in the awarding of the doctorate. Attribute lists provide evidence of the assumption at work: that the process of completing the STEM doctorate will furnish these competencies, and that these competencies can be performed for observers. The voice for being and becoming - that the interviews of this project attempted to unearth - are disregarded in the present STEM PhD model and policy pertaining to it. Perhaps this is because the vagueness and contentlessness that any discussion of being and becoming will encounter is uncomfortable ground for policy makers and the scientific community; for sure, it does not fit with the metrics of the attributes approach. Nonetheless, it is a voice of paramount importance. Batchelor proposes that if the voice for being is suppressed, then the voices for knowing and doing will suffer also. Liminal spaces and reflective practice would tend to the development of the voice for being, by providing a space that does not currently exist within the STEM PhD model for vulnerability, conflict, expectation, reality and the future self to be explored. Since the knowledge economy and liquid modernity demand continual learning and adaptation we can see that Batchelor's typology of voice has relevance for the contemporary scientific researcher

long after completion of the doctorate. As AC Grayling noted, '*the jobs of the future have not even been invented yet*' (2012).

7.6d Reform proposal three: exposure to sites of scientific knowledge production and application outside the university

Moving on from the more abstract notions of liminal spaces and reflexivity; on a practical level, exposure to, and experience of, various sites of scientific knowledge production and application outside the university would further encourage young scientists towards a liquid identity. This experience would reveal to young scientists a plethora of careers beyond academia and their previous work experiences. Formal opportunities within the STEM PhD that allow young scientists to experience the diversity of knowledge economy work sites, would leave them better prepared for the twists and turns of their future scientific careers. It would also counter the air of stigma associated with a move away from university science; something that clearly troubled the weak and strong pragmatists.

There are good grounds to believe that exposure to other areas of scientific knowledge production during the STEM PhD would stimulate a liquid identity formation; the main piece of evidence being the correlation between a young scientist's work experience and their moral position on the knowledge economy. It is striking that the third order capitalists, who welcomed the knowledge economy, were those individuals with the most diverse work experience. At the other end of the spectrum, the scientific purists shared very little exposure to scientific life outside campus. It would therefore seem plausible that by broadening the scientific experiences of young scientists, a broadening of their thinking about scientific identity and careers will follow. This reform would universalise the steps already being taken by some of the UK research councils, such as the research and policy placements presently offered by the Biotechnology and Biosciences Research Council (BBSRC) (BBSRC, 2012). However, it would diversify the type of placements offered - in industry, policy, science communication and so forth - and it would ensure that all young scientists, regardless of their discipline, experience a variety of placements.

7.6e Re-asserting agency

To close this part of the discussion, I revisit the *structure-agency* dualism to provide a final element of support for the liquid scientific identity. I have argued that the current approach to individuation employed by UK universities risks suppressing the agent at the expense of structure. Conversely,

individuation aimed at the evolution of a liquid scientific identity empowers the agent, so that the structures of the knowledge economy, together with unstructured energy of liquid modernity can be negotiated with insight. The conceptual distinction is that neither agency nor structure can be said to enjoy supreme dominance; but rather, that both agency and structure have causal efficacy. This means that the young scientist must understand the structures of contemporary scientific knowledge production, but that also, in light of this understanding, they possess the potential to manage and transform these structures, thereby reasserting individual agency.

Drawing once more from Margaret Archer's work, the concept of a liquid scientific identity is reminiscent of Archer's *analytic dualism*, which acknowledges the mutually constitutive relationship that exists between agent and structure (Archer: 20-22). Unlike Giddens' *structuration* thesis, which conflates agent and structure, Archer attempts to isolate each component when exploring the relationship that exists between them. This is well suited to the data from young scientists. Although young scientists were asked about the same structure - the knowledge economy - as we have seen, understandings and reactive behaviours were not uniform. Young scientists intended to behave very differently in response to the knowledge economy, meaning that it is reasonable to suggest that their chosen behaviour - participation or non-participation - has the potential to alter the architecture of the knowledge economy. Thus the causal efficacy of the young scientists transpires.

In analytic dualism, Archer acknowledges the interdependence of structure and agency, and details how the causal efficacy of each differs. For example, agent and structure operate on different time-scales; and while the effects of the agent tend to be local, a change in structure is more general in consequence. Archer's model shares liquid modernity's emphasis upon movement, generating the idea that while the knowledge economy and liquid modernity are structures that constrain young scientists to a certain degree, they are also open to revision. Archer's account suggests to us the possibility that the actions of young scientists today may bear upon the next generation of scientific careers. Under the lens of analytic dualism, the liquid model of identity is transformed into an open-ended account of how the scientific careers of young scientists may advance. In contrast, the first version of individuation suggested to us that scientific identity is a foregone conclusion, and that the structural dependence of young scientists is fixed. The depression of agency certainly makes for a troublesome read; however, the fatal limitation of the first type of scientific individuation lies in its dependence upon a modern understanding of identity and structure that is fast becoming obsolete.

7.7 Conclusion

This chapter has outlined the three major findings of the thesis: firstly, that young scientists are aware of the knowledge economy; secondly, that they express a moral position on it; and thirdly, that these moral positions, and young scientists' narratives of identity, lack sophistication and correspond to the outdated paradigm of modernity. I suggest at present, young scientists are encouraged by higher education policy and UK universities towards the formation of conceptually-wanting modern notion of identity. In response, I have advocated the idea of a liquid scientific identity as more fitting for both the present and future epistemic landscape, and I have shared a framework for how the STEM PhD may be reformed to assist young scientists in establishing an appropriately liquid scientific identity.

The knowledge economy and liquid modernity demand a scientist who can finally overcome the constraints of our epistemic heritage. It is the scientist who can transcend the dichotomies of nature and society; of science and the political; of the Enlightenment and Romanticism. The onus is now placed upon policy makers and universities to enable and empower young scientists by ushering them towards a liquid identity. Robust scientific knowledge production, and economic prosperity in the knowledge economy, will depend upon this.

8. Conclusion: Cosmopolitan futures; liquid identities

8.1 Restating the thesis findings and their significance

This thesis set out to answer three research questions, concerning: whether the knowledge economy is a known phenomenon to young scientists, whether they express a moral position towards it, and the impact that the knowledge economy has upon young scientists' constructions of scientific identity. We have seen that the knowledge economy is known to young scientists; that five moral positions have emerged in response to it; and, that these five moral positions inform five distinct types of scientific identity. I have argued that, common to all the five identities, is an affinity with modernity. Precisely, all young scientists understand scientific identity to be solid and stable. Three of the moral positions: the scientific purists, the socially-oriented and the third-order capitalists believe that they have already found their fixed scientific identity. The weak and strong pragmatists are yet to finally define their scientific identity; nevertheless, they aspire to an identity that is solid and stable.

This thesis has demonstrated that the knowledge economy is impacting upon the lives of young scientists currently studying towards a STEM PhD in the UK. In light of this, it has argued that young scientists must develop a scientific identity that allows them to handle the challenges of a scientific career in the knowledge economy. The significance of liquid modernity as an overarching context in which the scientist and the knowledge economy can be placed has been identified. Simply put, the knowledge economy and liquid modernity have transformed the landscape of contemporary science.

The consequence of this is that young scientists must forge their scientific lives amidst an environment where the modern pillars of reference and support fall away. As far as the project of identity is concerned, a scientific identity constructed along modern lines is unlikely to serve young scientists well. Nevertheless, we have seen that it is precisely the modern type of identity that universities encourage and that young scientists continue to construct for themselves; informed by their moral positions on science and the knowledge economy. Young scientists must instead be guided towards the construction of a scientific identity that can cope and adapt with continual change. A *liquid* identity serves as the best preparation for young scientists at the start of their career, since the journey of scientific life can no longer be planned.

In Bauman's terms, today's scientist ceases to be a *'pilgrim'* following the instructions of those that have gone before. The contemporary scientist is instead recast as the nomadic *'tourist'* (Bauman, 1995: 29). At present, young scientists who sample the nomadic mindset of the liquid scientist - namely the weak and strong pragmatists - speak of the stigma and unease brought about by openly admitting uncertainty and changing one's mind in scientific life. Both types of pragmatism are reactionary; a coping mechanism for these young scientists as they come to terms with the reality that an academic career in science is by no means the certainty that they assumed it to be when starting the PhD. The pragmatists struggle on; regarding their pragmatism as something of a temporary state to be endured until they secure a career path and a corresponding stable scientific identity. The story of the pragmatists highlights the extent to which the UK scientific community is failing to encourage young scientists towards a liquid identity appropriate for their futures; because, instead of viewing their pragmatism as a suitable or desirable long-term *modus operandi*, the pragmatists explain their position as a response to the uncertainty thrown up by letting go of their academic ambitions, to a lesser or greater extent. They do not expect that their future career and scientific identity will be characterised by pragmatism; on the contrary, they hope to eventually find the stability that academic science was once thought to offer, albeit in a different scientific context.

Of equal concern are the stories of the scientific purists, the socially-oriented, and third-order capitalists. These young scientists have not experienced a similar crisis of identity to that of the weak and strong pragmatists. Uncertainty and revision are completely absent from their narratives. The scientific purists, the socially-oriented and the third-order capitalists may want different things from their futures in science, but they are united by an intransigence and lack of sophistication when it comes to considering how their expectations may play out in reality.

I have speculated that the failing of UK universities to encourage young scientists to consider a liquid scientific identity has arisen because those who define policy are unaware of the extent to which the science profession is set to change in the knowledge economy and liquid modernity. To revisit Bauman's distinction, senior scientists who have successfully completed the *'pilgrimage'* continue to encourage their successors to do the same. Crucially, they are blind to the vantage point of the young scientist, who sees that the path and *raison d'être* of the pilgrimage has been eroded with time.

The STEM PhD ought to be modified in order to facilitate the formation of the liquid scientific identity. I proposed three reforms with the particular aim of supporting young scientists' towards a liquid identity. The first reform recommends the formation of *liminal spaces* within the STEM PhD, in order to foster interdisciplinary discussion and broaden the horizons of how young scientists think about science and its place in the world. The second reform proposes the introduction of reflective practices into the STEM PhD, on the judgement that *reflexivity* would heighten the socio-political awareness of young scientists, and move them towards a fluid understanding of identity, nurtured by the constant process of examining their beliefs and actions. It is through reflexivity that the outmoded modern identities and the unrealistic expectations of scientific life could be finally deconstructed; since young scientists would come to see the irrelevance of their beliefs to the reality that surrounds them. The third reform advocates the inclusion of placements in *sites of scientific knowledge production and application other than the university* throughout the STEM PhD. In exposing young scientists to the diverse array of scientific knowledge production sites in the knowledge economy, their expectations would further align more closely to reality, and the aforementioned stigma of a scientific career in the knowledge economy - of concern to all young scientists except the third-order capitalists - would be effectively confronted. The realisation of these reforms requires the support of those involved in researcher development at the local and national level. Individuals responsible for researcher development within universities, along with policy makers, need to understand the rationale for, and be convinced of the case for, the liquid scientific identity. Practitioners and policy-makers involved with the Roberts' agenda have done much to transform perceptions on the transferability and broad value of doctoral-level STEM skills, and of the ready adaptability of STEM doctoral researchers. The cultivation of a liquid scientific identity can be seen as building upon these sure foundations, to keep pace with the supercomplex world of contemporary science, and to ensure that young scientists are best prepared for the scientific life that awaits them. The publication of a short summary of the thesis' main arguments, for circulation at the host institution, will be one way to promote the proposed reforms. If the reforms are taken up, I would of course advocate an ongoing evaluation of how useful young scientists find the measures to be.

At the national policy level, the narrative of the knowledge economy ought also to be broadened and diversified so as to be more visible and attractive to young scientists. Clearly, the present approach is not working. Young scientists have an unsophisticated understanding of what the knowledge economy is, and for most, it is a 'second-option' to a career in university science. This

perception is itself based on a flawed assumption; because the university is not immune from participation in the knowledge economy. Indeed, it is a central piece of the knowledge economy infrastructure and this has amounted to a historic transformation in its functions. Science studies scholars have long argued that the scientific community needs to be more honest about the complex reality and social situatedness of its craft. Encouraging transparent discussion on the nature of contemporary science would assist young scientists further as they navigate their way to a liquid scientific identity. It would suggest to them that trial, error, uncertainty and revision are routine and therefore acceptable parts of normal scientific life. Likewise, policy makers need to be more honest and accountable in their depictions of the knowledge economy. Young scientists must be included in this discussion, since their support for, and participation in, the UK knowledge economy will be key to determining its long term sustainability and prosperity.

The narrow vision of the policy narrative of the UK knowledge economy has a homogenising effect on its subject matter. It dilutes ‘knowledge’ to scientific knowledge that is of demonstrable economic value; and reduces ‘economy’ to neoliberal capitalism. Furthermore, only the formal monetary transactions of the neoliberal economy count in the policy narrative. The consequence of this restrictive narrative is that young scientists respond to it in an equally narrow-minded way. It is either a context in which they would like to forge their scientific career, or it is not. Young scientists do not appear to realise that a scientific life lived ‘outside’ the knowledge economy is now a thing of the past. The idea of the liquid scientist who embarks upon a scientific career that traverses the many sites of the knowledge economy, and enjoys the diversity that its choices bring, is far from celebrated by young scientists. Furthermore, the message that young scientists are vital to the knowledge economy, since their skills and knowledge are so widely valued, has not been effectively circulated. Encouraging young scientists towards a liquid identity also necessitates the right signals being sent from the national policy level.

8.2 Addressing the limitations of the thesis

All research is bound by limitations, and this project is no exception. On a more positive note, identifying the shortcomings of the research reveals to us potential research endeavours for the future. There are five such possible opportunities for future research arising from the project that I will now briefly consider.

The first piece of research would explore more deeply the relationship between information set and moral values in determining the identities and strategies of young scientists. Simply put, the research question would inquire which of the two variables yielded a greater influence. This research would generate greater insight into how young scientists form their scientific identity, and it would have implications for policy makers also; because as I argued in chapters six and seven, robust evidence-based policy for skills-training and science careers must acknowledge the importance of normative values in shaping the career ambitions of young scientists.

The second piece of research would address the limitation arising from the fact that this research dealt only with young scientists. In chapter seven, I argued that:

Consciously or not, young scientists promulgate a modernist account of science and identity. They share modernity's ambition of creating solid and stable identities.

(p. 219)

The obvious response to this comment is: don't all young people aspire to the solidity and stability? Youth is a continual process of being and becoming, in all aspects of one's life, not just professionally. Therefore, is the desire for solidity and stability simply a short-term coping mechanism amidst the routine upheaval of youth? One way that we could explore this potential weakness of the thesis is to conduct similar research with senior scientists. We could ask the same three research questions of scientists who are no longer defined by their youth, and consider the implications of the knowledge economy for the senior scientific identity. While the results regarding senior scientists would not necessarily invalidate the data from young scientists, it might suggest that project of scientific identity in the knowledge economy is responsive also to age and experience. In other words, young scientists' reliance upon the paradigm of modernity may say more about their youth or inexperience than it does an endemic lack of preparedness across the scientific community.

A third project would extend the successful research of this thesis to another institution, and would feature early-career HASS researchers. In the methodology chapter (4), I argued that the host institution of this study made for a fitting choice, because it dealt exactly in the sort of knowledge creation and human capital training that knowledge economy policy prioritises. I maintain this argument, however I think a necessary development to this research would look at an institution

with which the narrative of the knowledge economy does not fit quite so easily, and for a group of researchers whose knowledge and skills are not explicitly desired by knowledge economy stakeholders. Their moral position on the knowledge economy, and the question it prompts for their researcher identity, may provide even more interesting and extreme data than we have seen in the present study.

A fourth avenue of research would consider the project of liquid identity in knowledge-intensive professions other than science. This proposal would extend the focus of the present study from scientific identity to liquid identity construction in other knowledge-intensive professions; allowing for a consideration of how far the findings relevant to young scientists have resonance in other professional contexts. The rationale for looking at other knowledge-intensive professions is that they too have experienced a similar transformation to science in the knowledge economy; as the modern boundaries between academia, industry, state and society fall away, and information and communication technologies advance. Possible professions include advertising, finance, insurance, education and health; although part of the study could indeed tackle the question of what defines a knowledge economy job - something that scholars and policy-makers continue to disagree on.

The fifth research idea would consider the implications of the liquid model of scientific identity for the integrity of science. If scientists are encouraged towards a strongly pragmatic mind-set; in which all types of scientific knowledge creation and application are tolerated, and chameleon behaviour is the norm; what does this mean for the credibility and integrity of science - the modern source of which sprung from the distance between scientist and the state, industry and society? If scientists are recast as more socially, politically and economically involved than their modern predecessors, will the neutrality and authority of modern science be forever lost? Or, as Steve Fuller and Helga Nowotny have argued, will the exposure of science as a very human activity actually increase public trust in, and veneration for, science? (Fuller, 1998b; Nowotny 1999) Can the integrity of science in the knowledge economy and liquid modernity be secured through the transparent interestedness of liquid science? This project would involve the collection of a wide variety of stakeholder views - citizens, industrialists, politicians and scientists - in order to explore whether the liquid modern model of scientific identity is complementary to the future integrity and authority of science.

8.3 *Cosmopolitan futures; liquid identities*

This thesis has argued that the knowledge economy is a cosmopolitan space of scientific knowledge production and application. The university is part of the knowledge economy, and is changing because of it. The wealth of scientific career paths that the knowledge economy offers, within and beyond the university, should mean that no young scientist will feel precluded from it.

This is not to deny that the knowledge economy presents challenging and complex moral questions for young scientists; but in a sense, *all* scientific activity does. The arrival of the knowledge economy and liquid modernity has not only added complexity to the relationships between science, the economy, state and society; it has made these complex relationships harder for the scientist to ignore. The nomad scientist - unafraid to act and think independently, and with a politically and socially aware *liquid* identity - should not be understood as merely a more appropriate identity for the times we face; but as a *superior* model of scientific identity than we have historically imagined.

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Websites

The Association of Universities in the East of England (AUEE) <http://www.auee.ac.uk/>

The Biotechnology and Biosciences Research Council (BBSRC) <http://www.bbsrc.ac.uk>

The British Educational Research Association (BERA) www.bera.ac.uk

The Engineering and Physical Sciences Research Council (EPSRC) www.epsrc.ac.uk

The Research Excellence Framework (REF) <http://www.REF.ac.uk/>

Science is Vital <http://scienceisvital.org.uk>

UK Office for National Statistics Publication Hub www.statistics.gov.uk

Vitae www.vitae.ac.uk

Appendix 1 Focus group question schedule

Introductory Question:

1) When you hear the term 'knowledge economy' what is the first thing that comes to mind?

Context Questions

1) What do you know about New Labour's Higher Education policy since 1997?

- Can you state the aims of Higher education policy?

3) What do you understand by the division between 'liberal' and 'vocational' education?

4) What do you think is the traditional purpose(s) of the University?

5) What do you think is the purpose of the university today?

6) Have you heard of the term 'academic freedom'? What do you think 'academic freedom' might mean in practice?

7) Have you heard of the term 'academic capitalism'? What do you think 'academic capitalism' might mean in practice'?

The PhD Experience

1) What do you think is the purpose of the PhD degree?

2) What were your own reasons for deciding to undertake your PhD?

3) How did you decide which subject to study at PhD?

4) How much independence did you have in the design of the PhD project?

5) How much independence do you feel you have in managing the day-to-day of your PhD project, and its future direction?

6) Does the utility of research project matter to you?

Note: probe about being useful with a practical purpose, not just in a subjective sense. E.g. might be technological, economic, political, and social.

7) Do you feel your PhD project is engaged with the wider world?

-Explain why and how.

8) Do you have any links with business, government or other bodies through your project?

E.g. are they stakeholders/ funders etc?

9) What do you think is the most important personal value/ outcome what one takes away from completion of a PhD?

10) What are your own individual hopes for life after the PhD?

- e.g. career choices

-do you want to continue as a researcher?

11) What are the greatest pressures of doing a PhD

12) Do you think it is important to publish your research, and why?

13) What do you think are the main differences between science PhDs and humanities PhDs?

Note: probe respective value, contribution, importance?

Observations of supervisors/ academics

1) If you had to write a general job description for an academic, what would the main responsibilities be?

2) What do you think is the most important contribution of the academic?

3) What do you think are the greatest pressures in academic life?

4) For those of you who suggested they might like to be an academic in Q19, what were your reasons for this? For those who do not want to be academics, what were your reasons?

5) For those of you who want to continue in research, can you think of other environments where you might like to conduct research after your PhD?

6) What do you think are the main differences between academic and non-academic research cultures?

Note: positives and negatives welcomed

Closing Questions

- 1) Given your thoughts on the knowledge economy, what do you think is the contribution of the university in such a system?

- 2) Do you think that the 'knowledge economy' is a positive, negative or neutral development for the PhD researcher?

Appendix 2 Introduction to online survey

About Online Surveys | Support | Contact Us

PhD students in the Knowledge Economy

Imperial College London

My Surveys Create Survey My Details Account Details Account Users

Thank you for taking part in this questionnaire.

You have been selected to take part in this study as a UK PhD student in the STEM (Science, Technology, Engineering, Mathematics) subjects at Imperial College. Please do not proceed if this does not apply to you.

The questionnaire will involve tick boxes with some open questions. There are no right or wrong answers; the questionnaire is exploratory and designed to reflect your experiences as a PhD student.

Your participation in this research is **voluntary**. All information will remain **anonymous** and **strictly confidential**. Our procedures for handling, processing, storage and destruction of the data are compliant with the **Data Protection Act 1998**.

The results of the research will form the basis of the PhD thesis of **Sally Hancock, Graduate Schools research assistant** and other related publications. You will be able to contact Sally for a copy of any such outputs.

The project is supervised by Ms. Elaine Walsh (Senior Lecturer, Graduate Schools), Dr. Stephen Webster, Head of the Science Communication Group and Dr. Gwyneth Hughes (Institute of Education, London). It has been granted ethical approval by the Imperial College Ethics Committee.

If you wish to be included in the prize drawer, please leave your contact details when prompted in the final section of the questionnaire.

Thank you once again for taking part!

Note that once you have clicked the CONTINUE button at the bottom of each page you can not return to review or amend that page.

[Continue >](#)

Appendix 3 The online survey

| Online Surveys | | Imperial College London | |
|---|--|-------------------------|-----------------|
| Develop, launch and analyse Web-based surveys | | My Surveys | Create Survey |
| | | My Details | Account Details |
| | | Account Users | |

Main Survey Page

Note that once you have clicked on the CONTINUE button your answers are submitted and you can not return to review or amend that page

Personal Information

1. Please state your age

2. Please state your gender:

3. Please state your department:

If you selected Other, please specify:

4. Please state the date you started the PhD:

| | |
|----------|----------------------|
| a. MM/YY | <input type="text"/> |
|----------|----------------------|

5. Please indicate the status of your PhD study:

6. Please indicate your year of study:

7. Please indicate your source of funding:

If you selected Other, please specify:

8.

| | INSTITUTION | DEGREE | MM/YY-MM/YY |
|--|----------------------|----------------------|----------------------|
| a. Please state if you studied at universities other than Imperial before beginning the PhD. Please begin with the most recent . | <input type="text"/> | <input type="text"/> | <input type="text"/> |
| b. OTHER | <input type="text"/> | <input type="text"/> | <input type="text"/> |
| c. OTHER | <input type="text"/> | <input type="text"/> | <input type="text"/> |

9.

| | EMPLOYER | POSITION | MM/YY-MM/YY |
|---|----------------------|----------------------|----------------------|
| a. Please state any work experience you have had since beginning Higher Education (i.e. from the time you began your first degree) | <input type="text"/> | <input type="text"/> | <input type="text"/> |
| b. OTHER | <input type="text"/> | <input type="text"/> | <input type="text"/> |
| c. OTHER | <input type="text"/> | <input type="text"/> | <input type="text"/> |
| d. OTHER | <input type="text"/> | <input type="text"/> | <input type="text"/> |

The Knowledge Economy

10. Have you heard of the term 'knowledge economy'?
 Yes No

11. What do you think is meant by the term 'knowledge economy'

12. Do you think a 'knowledge economy' already exists in the UK? Please give the reason(s) for your answer.

13. If you answered yes, what do you think has caused the shift to a knowledge economy?

14. Since New Labour were first elected in 1997, what do you know of their Higher Education policies? Please list all that you can think of.

The University

This section will examine the university in a **historical context** (i.e. **19th - 20th C.**) before moving to consider the **modern** (i.e. **today's**) university.

There may appear to be some repetition in the question items, so please bear in mind the **different time periods** being asked about.

15. Historically, what do you think the function(s) of universities were?

16. Using your answer to the question above, please indicate the importance of the possible functions of historical universities:

| | Extremely Important | Important | A Little Important | Not Important |
|--|-----------------------|-----------------------|-----------------------|-----------------------|
| a. Teaching | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| b. The generation of new knowledge | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| c. Creating critical thinkers | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| d. Conveying a particular message, e.g. Religion or Scientific Enlightenment | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| e. Advocating 'higher' arts and culture | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| f. A 'necessary' transition for young people | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| g. Training and employing academics | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| h. Enhancing social mobility | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| i. Creating a socially elite group of individuals | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| j. To hold the State/ government to account | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| k. Equipping individuals with a technical skill | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| l. Preparing individuals for a particular profession | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| m. A profit-making organisation | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| n. Interacting with industry | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| o. Keeping unemployment figures low | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| p. Interdisciplinary dialogue and research | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| q. To benefit the economy | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| r. OTHER - Please state below | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

17. Please state OTHER and indicate importance.

18. What do you think are the function(s) of modern universities?

19. Using your answer to the question above, please indicate the importance of the possible functions of modern universities:

| | Extremely Important | Important | A Little Important | Not Important |
|--|-----------------------|-----------------------|-----------------------|-----------------------|
| a. Teaching | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| b. The generation of new knowledge | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| c. Creating critical thinkers | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| d. Conveying a particular message, e.g. Religion or Scientific Enlightenment | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| e. Advocating 'higher' arts and culture | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| f. A 'necessary' transition for young people | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| g. Training and employing academics | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| h. Enhancing social mobility | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| i. Creating a socially elite group of individuals | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| j. To hold the State/ government to account | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| k. Equipping individuals with a technical skill | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| l. Preparing individuals for a particular profession | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| m. A profit-making organisation | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| n. Interacting with industry | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| o. Keeping unemployment figures low | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| p. Interdisciplinary dialogue and research | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| q. To benefit the economy | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| r. OTHER - Please state below | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

20. Please state OTHER and indicate importance.

The PhD

21. What do you think is the role of the PhD degree?

22. Thinking of your personal decision to undertake a PhD, please indicate how the following statements reflect your motivations.

| | Strongly Agree | Agree | Disagree | Strongly Disagree |
|--|-----------------------|-----------------------|-----------------------|-----------------------|
| a. I wanted to generate new/ original knowledge | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| b. I wanted to learn as much as possible in my chosen subject | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| c. I wanted to experience a period of academic freedom | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| d. I wanted to become an independent researcher | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| e. I wanted the training for an academic career | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| f. I wanted preparation for a successful career outside academia | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| g. I wanted to develop niche expertise | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| h. I wanted to develop a broad skills-set | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| i. I wanted to generate research which is 'objectively' useful i) Economically | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| j. ii) Politically | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| k. iii) Socially | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| l. iv) Technologically | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| m. I wanted to generate research which has personal significance to me | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| n. I wanted to delay decision-making about life beyond education | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| o. I wanted to a tangible qualification to prove the depth of my knowledge | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| p. I wanted to publish academic papers | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| q. The funding was available | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| r. My supervisor offered the project | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| s. An employer offered the project | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| t. An employer offered funding | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| u. The project had good career prospects | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| v. The project was tied to a research team I wanted to join | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| w. I wanted to develop a start-up company related to my PhD knowledge | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| x. I wanted to develop an idea which was completely my own | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| y. The project was tied to a prestigious university | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| z. OTHER - Please state below | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

23. Please state OTHER and indicate importance.

24. Please now indicate the importance of the following functions of the PhD in general:

| | Extremely Important | Important | A Little Important | Not Important |
|--|-----------------------|-----------------------|-----------------------|-----------------------|
| a. Generating new/ original knowledge | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| b. A period of academic freedom | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| c. Pursuing an individual's interest in their chosen subject | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| d. Training for an academic career | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| e. To develop niche expertise | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| f. To become an independent researcher | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| g. To develop a broad skills-set | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| h. To prepare an individual for a successful career outside academia | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| i. To generate research which is 'objectively' useful: i) Economically | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| j. ii) Politically | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| k. iii) Socially | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| l. iv) Technologically | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| m. To generate research which has personal significance to the individual candidate | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| n. To delay decision-making about life beyond education | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| o. Providing a tangible qualification to prove an individual's depth of particular knowledge | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| p. To publish academic papers | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| q. OTHER - Please state below | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

25. Please state **OTHER** and indicate **importance**.

26. Educational theorists categorise the reasons for conducting research as either **academic** or **instrumental**. **Academic** refers to the research being an end in itself, i.e. knowledge for the sake of knowledge. **Instrumental** refers to the research being a means to an end, i.e. knowledge for the sake of economic, political, or social gain. If you had to categorise **your own reasons** for undertaking your PhD, which description would be most accurate?

Instrumental Academic

27. How much **freedom** did you have in **defining** your PhD project?

Absolute Quite A Lot Only A Little None

28. Please give the reason(s) for your answer:

29. If a **new research topic** arose in the course of your PhD, would you have the freedom to pursue it should you wish?

Yes No

30. Please give the reason(s) for your answer:

31. Do you feel as though your PhD is **connected with the wider world**?

Yes No

32. Please give the reason(s) for your answer:

33. Do you think it is **important to publish academic papers** from your PhD research?

Yes No

34. If you answered **yes**, please indicate **why** it is important to publish from your PhD research:

| | Extremely Important | Important | A Little Important | Not Important |
|---|-----------------------|-----------------------|-----------------------|-----------------------|
| a. To provide peer-reviewed feedback | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| b. To satisfy my funders | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| c. The achievement of a personal goal | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| d. For future job prospects | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| e. To share knowledge with the academic community | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| f. To develop my skills, e.g. writing, working to deadlines | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| g. Because my supervisor expects me to publish | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| h. To attract continued or new funding | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| i. To compete with fellow researchers | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| j. OTHER - Please state below | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

35. Please state **OTHER** and indicate **importance**

36. Do you encounter the following **stressors** in your PhD? Please indicate **how stressful** these are:

| | Extremely Stressful | Stressful | A Little Stressful | Not a Stressor |
|---|-----------------------|-----------------------|-----------------------|-----------------------|
| a. Dealing with continual uncertainty | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| b. Pressure to publish | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| c. Having to satisfy my supervisor | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| d. Not having enough time to complete my research | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| e. Having to satisfy my sponsor | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| f. Not having enough freedom with my research | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| g. Having too much freedom with my research | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| h. Research not going to plan | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| i. Feeling as though I am not good enough | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| j. The PhD taking up all of my time | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| k. OTHER - please state below | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

37. Please state **OTHER** which describes a significant stressor to you

38. How do the following statements reflect your **career intentions** post-PhD?

| | Strongly Agree | Agree | Disagree | Strongly Disagree |
|--|-----------------------|-----------------------|-----------------------|-----------------------|
| a. I want to have an academic job | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| b. I want a career in research in the public sector | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| c. I want a career in research in the private sector | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| d. I want a career outside academia which doesn't involve research | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| e. I might go into academia if I cannot think of anything else to do | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| f. I will choose the job where I can earn as much money as possible | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| g. I will choose a job related to my PhD subject | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| h. I am not yet decided what I want to do | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| i. I am not yet thinking about careers | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| j. OTHER - Please state below | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

39. Please state **OTHER** which describes your career intentions more accurately

The Academic Profession

40. How important do you think the following **duties of an Academic** are?

| | Extremely Important | Important | A Little Important | Not Important |
|--|-----------------------|-----------------------|-----------------------|-----------------------|
| a. Research | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| b. Teaching | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| c. Pastoral care | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| d. Mentoring | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| e. Providing a role model | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| f. Inspiring a new generation of academics | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| g. Supervising PhD students | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| h. Generating knowledge for politicians | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| i. Generating knowledge for industry | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| j. Setting exams | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| k. Providing feedback to students | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| l. Disseminating their knowledge to the public | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| m. Pursuing their personal research interests | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| n. Securing research funding | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| o. Generating profitable income for the university | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

FINAL QUESTIONS

41. Do you think academia is linked to the economy?

Yes No

42. Please give the reason(s) for your answer:

43. If you answered **yes**, do you think academia has **always** been linked to the economy?

44. Which of the following statements do you think most accurately reflects the **relationship** between **academia** and the **economy**:

- Academia and the economy influence each other equally
 The economy has influence over academia
 Academia has influence over the economy

45. Many theorists have identified **characteristics** of a **knowledge economy**. Thinking about **your PhD experience**, have you observed or experienced any of the following?

| | Yes | No |
|---|-----------------------|-----------------------|
| a. Academics giving an increasing amount of their research time to industrial research | <input type="radio"/> | <input type="radio"/> |
| b. Encouragement of PhDs and other researchers to be 'entrepreneurial' | <input type="radio"/> | <input type="radio"/> |
| c. Encouragement of PhDs and other researchers to sell their research where possible | <input type="radio"/> | <input type="radio"/> |
| d. Active recruitment by your university of international students | <input type="radio"/> | <input type="radio"/> |
| e. Supervisors dedicating more time to students whose research is sponsored by industry | <input type="radio"/> | <input type="radio"/> |
| f. PhD students undertaking their degree primarily for its potential economic reward | <input type="radio"/> | <input type="radio"/> |
| g. Different treatment - from industry and the government - between arts/ humanities/ social science subjects and science/technology/ engineering/ mathematics students | <input type="radio"/> | <input type="radio"/> |
| h. Declining freedom in the choice of research topics open to the academic/ PhD researcher | <input type="radio"/> | <input type="radio"/> |
| i. Growth of multidisciplinary research | <input type="radio"/> | <input type="radio"/> |
| j. Greater concern for global university rankings | <input type="radio"/> | <input type="radio"/> |
| k. Pressure to conduct research which is applied (e.g. 'instrumental') rather than pure/basic (academic) | <input type="radio"/> | <input type="radio"/> |

46. Given your understanding of a knowledge economy, stated in Q11), what do you think would be the **most important** function of a **university** in such a system?

48. Do you think the knowledge economy is a potentially neutral, negative or positive development for the **university**?

Neutral Negative Positive

Please give the reason(s) for your answer:

49. Do you think the knowledge economy is a potentially neutral, negative or positive development for the **PhD student**?

Neutral Negative Positive

Please give the reason(s) for your answer:

PRIZE DRAWER & CONTACT DETAILS

50. Thank you once again for your participation.

The research team will be conducting follow-up **interviews** to explore issues from the questionnaire in more detail. If you would like to participate in an interview, which will **last no more than one hour**, at a time convenient for you, and for which you will receive a **£10 Amazon voucher** please leave your contact details below.

These will be stored separately from the data to ensure your anonymity.

Please proceed to the final section to be entered into the Prize Drawer.

| | |
|--------------|----------------------|
| a. Name | <input type="text"/> |
| b. Email | <input type="text"/> |
| c. Telephone | <input type="text"/> |

51. If you wish to be included in the **Prize Drawer** to win **one of 20 £10 Amazon Vouchers**, please leave your contact details below.

These will be stored separately from the data to ensure your anonymity.

Winners will be contacted in early September 2010.

| | |
|--------------|----------------------|
| a. Name | <input type="text"/> |
| b. Email | <input type="text"/> |
| c. Telephone | <input type="text"/> |

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Thank you for completing this questionnaire.

Appendix 4 The interview schedule

Brief introduction to myself, the project, and interview length (should not exceed 1 hour). Run through ethical obligations, issues of consent and right to withdraw once again. Consent form signed.

1. At the time of completing the online questionnaire, you stated that you [did/ did not] know of the knowledge economy, and here is the definition you gave:

Almost one year later, has your answer changed in any way? Do you know more or less about the knowledge economy? Would you alter your definition? If your answer has changed, how do you account for this change?

2. In the questionnaire, you stated that the knowledge economy was a [positive/ negative/ neutral] development for the university, and here is your explanation as to why:

If I asked you the same question today, would your answer have changed? If it has, how might you account for this change?

3. You also stated that the knowledge economy was a [positive/ negative/ neutral] development for the STEM PhD student, and here is your explanation as to why:

If I asked you the same question today, would your answer have changed? If it has, how might you account for this change?

4. Can you explain to me your reasons for choosing a STEM PhD?

5. As a STEM PhD student, what encourages you to keep going on with your research?

Probes: How many have in sight the goal of producing applied knowledge? Or, of the entrepreneur in the marketplace: producing economically useful knowledge? Do they think they are contributing to the economy, and is the thought of whether they are/ aren't a concern? This could be in terms of skills, knowledge transfer, direct research output etc.

(Note: this may have arisen from Q.4)

6. Did you have an idea of what the STEM PhD was going to be like, and if so, is the experience living up to your expectations? Yes/ No? Talk me through why.

Note: Probe especially on the issue of academic freedom and the nature of work making up the PhD.

7. In the questionnaire, you stated that you think your PhD work [is/ is not] connected with the wider world. Perhaps you can talk me through your reasons for stating this, or tell whether your views have changed.

If you acknowledged a connection to the wider world in your PhD research, does this present a problem to you when you think about scientific principles such as: bias, objectivity, pure knowledge, the nature/culture divide? [Or perhaps this is something they have not thought about]

Probe: Is there a point/ are there certain external pressures that are seen as being problematic to the STEM PhD student as they attempt to pursue their research?

8. What do you think your STEM PhD is preparing you for? In what way(s)?

Probe: for an academic career; for a job outside academia; skills for the (knowledge) economy.

9. Imagine you have to explain to a complete outsider, an alien to the UK and its PhD practices, about what you are doing and why. You have to convey to them your identity, as a STEM PhD student - but without drawing upon this label. How do you explain your status, your activities?

Probes: training to be an academic; an apprentice (to whom: academia or industry); an independent researcher; a student; a scientist; a technician; a young professional; a problem-solver; a future knowledge worker; a member of a community (of scholars?); a civil servant; a bridge between academia and industry...

10. What element of your activities as a STEM PhD student is/ are the most important in determining what it means (to you) to be a STEM PhD student? Perhaps there is not just one.

11. Think about how you have just labeled yourself and identified your primary activities - which I hope has captured your opinion of the very essence of what it means to be a STEM PhD. Now consider you are a member of management at your university - Imperial College London. How do you think they would they define the purpose and activities of their STEM PhD students?

(Does this present congruence or a contrast with their own understandings, and efforts to progress?)

12. Next, imagine you a member of the current UK coalition government. How do you think they would explain the purpose and activities of the STEM PhD population?

Note: I am attempting to uncover the most important, defining, feature of identity from all perspectives (as according to the interviewee).

13. You've explained to me how you define the most fundamental aspect of your status as a STEM PhD student. Now I'd like to think about how your PhD research has been shaped. You can draw from how the overarching questions came to be, or the incremental developments - day to day in the lab. How has your research been affected by influences that I call 'internal' to the university, or the lab (e.g. other PhDs, your supervisor, post-Docs etc), and how has it been influence by forces which appear to be 'external' to the university or the lab (wider economic, social political trends, funding constraints, social relations outside the lab)? Is this internal/external divide something you are aware of, or relate to, or do all the elements combine within your PhD research? Rational and extra-rational influences: awareness of them and an appraisal of how much influence they have.

14. How do you define scientific innovation?

Probe: is it long-term, short-term? How does scientific innovation relate to technological innovation? Perhaps it is unrelated?

15. As a STEM PhD student, do you think you orchestrate/ contribute to scientific innovations?

Probe: is the PhD seen as a conservative or innovative process? Do STEM PhDs reinforce or challenge existing scientific paradigms? What is the balance between management of knowledge, applications of existing knowledge to novel situations, producing knowledge that is deemed to be completely new?

16. What are your post-PhD career aspirations? Has this changed since beginning the PhD; if so, in what way(s), and why?

17. There's been a real push to get more and more individuals to study STEM subjects in the UK. You're a STEM PhD. Do you welcome this policy? Please explain why/ why not. Why do you think this policy is in place? Do you have any thoughts on its rationale?

18. Presumably, if we have more and more individuals studying STEM at A-Level and for their undergraduate degree, we'll have more individuals for whom the option of undertaking a STEM PhD becomes a genuine reality. Is this a good thing? Why/ why not?

19. Beyond these qualifications, what qualities do you think individuals looking to undertake a STEM PhD at a research intensive university like Imperial need to possess? I'm interested specifically in personal attributes... or perhaps, you could tell me whether 'the person' at all matters when it comes to studying for the STEM PhD today. Please explain your thoughts.

20. Is the knowledge economy a motivating discourse for you, as a STEM PhD? Or, does it present difficulties with your evaluation of yourself as a STEM PhD: your identity and purpose?

Any other questions/ issues.

Appendix 5 A sample of the transcripts: a) George and b) Will
*(selected to represent two distinct moral positions: strong pragmatism
and third-order capitalism)*

a) The UK knowledge economy and STEM PhDs interview 11: George

Interview length: 55 minutes

[1]⁴⁰

SH: So last year, when asked about the knowledge economy in the questionnaire, you said ‘no’ to having heard of it, but defined it as: ‘the job opportunities afforded to people with advanced degrees, and ways of making money from intellectual property, spin-off companies created by universities, research and research groups. The attraction of paying students, particularly foreign students, given the higher fees they pay to university courses: essentially selling them education and knowledge’. In my own understanding, that’s a well-informed answer. One year on, are you still happy with this definition?

George: Yes, I think so. I suppose there’s also the other thing that I guess I’d want to add to that as well as I guess here and export or in terms of education these institutions, but there’s a, it would take a sort of, part of the structure of a different kind of economy, one that’s based on more high tech industry, stuff that needs a lot more training. So, I suppose your knowledge economy is kind of structuring things to any kind of high tech industry, so yes, various types of computer programming and software design and anything that needs a high level of mathematics or language skill. Even things like linguistic training and analysis, so a new technique. I guess yes, that’s the only thing I’d add. That’s not very well articulated but in some way it forms part of a structure in a lot of other sort of sometimes small but kind of niche, highly specialised industries.

SH: At the time you said you hadn’t heard of it. Have you heard it in the past year?

[2]

George: I think I’ve heard it used a few times. I don’t think I’ve really engaged with it very much; but yes, I’m quite broadly aware of it now and yes, it has been referred to in a few speeches and a few articles.

⁴⁰ Original page number from unedited transcript, as referred to in the thesis.

SH: I also asked whether you thought the knowledge economy was a positive, negative or neutral shift for the university. Here you said neutral, giving the reason that: ‘depending on how clearly the value of university functions are thought about it could positive or negative. It has the potential to homogenise the university into a technical training academy, or to focus research and bring better funding for all programmes’. Are you still in agreement with this answer?

George: Yes, I think so. I mean I would think that without careful thought about what function you wanted an institution to have then it would probably have a negative effect on the institution. So, if you’re not taking care to kind of construct your philosophy of value and what it is you want your role to be, what it is, yes, what you want to happen then you can probably unthinkingly start producing more universities or something like that or, and are just not satisfying to anyone that no one, they don’t have any kind of culture as such. Yes, no, I think I’d agree with that because when I was doing the questionnaire the process of filling in the questionnaire made me think about it, so between the beginning and the end of the questionnaire I’d developed my thoughts quite a lot. So, yes there’s a difference maybe between what I started saying at the beginning, what conclusions I came to by the end. So yes, I think it’s neutral, it’s not inherently good or inherently bad but we can go either way.

SH: In terms of it being a ‘balanced’ situation, hence neutral, do you see any evidence of it heading one way of the other?

George: I don’t know, I suspect it’s that universities are becoming more I’m thinking the market orientated and more homogenised. I don’t know, so there’s the funding squeeze that’s going on at the moment, which isn’t great so you’ve got these ridiculous situations with departments closing and funding being cut. The UK having to pull out of various other -- projects that I think I saw someone Tweet yesterday that the nursing school in Glasgow is going to be closed despite being the second best in the country, so there’s these odd things happening. So, you’ve got that problem, you’ve got this and no one’s quite figured out how to fund universities given that there was a massive push for more places to be offered. So, I suppose it happened in 97 or 98 with Tony Blair’s great drive to have more people in higher education, so this created a question that’s not ever really going to be resolved and so obviously there’s been a lot of anger about it recently. How

[3]

do you go about funding this, who should fund it? I don't think it's adequately been thought through. So yes, that's caused a lot of problems for universities in terms of how they fund themselves and so I think that is going to make some close and make them all fight for this middle ground which I think does tend to homogenise. Plus you do have this ridiculous open market effect where I think forensic science is the best example I know of this, where you have something like 150 jobs for it in the UK, I think maybe full stop, not per year and yet you've got thousands of graduates every year who graduate from forensic science. So the question of value, why are we training people in this or, I mean okay if that's what you want to do but don't pretend that your degree is somehow, this particular degree which is a sort of very specialised kind of training is there to give you, I don't know, a skill set useful for what exactly? So there's some incompatibility in that kind of service sector economy. I'm giving myself a skill set which I will then apply to things, so there's a conflict between that and then the, you have the older, higher ideal education for its own sake and that kind of purity of purpose and blue sky thinking and the things that can come from that. So yes, there are these conflicts between that and the new idea of yes, just, unthinkingly opening up new universities and new courses for market forces. Markets are a useful tool but only in the right context I suppose. Does that make sense? I don't know.

SH: For the PhD student, you also said the knowledge economy was a neutral shift, because: 'It could go either way. More funded places could create links with a broader understanding of society, and the impact of universities but there is a risk of shutting down some subjects and restricting academic choice and freedom'. Are you still happy with this answer?

George: Yes. Yes I think with freedom, I guess that would be down to how you're going about funding your PhDs. I mean really there are problems with what topics are hot in terms of where the funding is anyway, which to study. So, I mean some sort, yes, sponsoring PhDs and... Yes, if you're just, if you're trying to just fund things because you think they'll be useful then you'll get a lot of people maybe playing around with lasers trying to do some kind of research that's benefitted to just focus on manipulating a couple of atoms but then you'll ignore, but then other areas will be massively underfunded that could potentially be very useful for that or other things. It's not really clear, so how does, to see if they create or are the kind of causal links of research, so what's useful for, I mean if you were funding ridiculous particle physics in the 50s and 60s you wouldn't have the medical tech that you have now. So, there's that. Again, you get odd developments coming from kind of industry funding. So, where in the 80s a lot of the physicists went into the kind of the

financial sector, they started kind of magnetising and doing a lot of things with the kind of statistical analysis of financial markets, which has now created a market for

[4]

financial mathematics, which is now this subject that's just been created out of nowhere and it's maybe not even really that useful. But somehow with all this kind of interest on funding you've got your financial map and each department's groups being set up and all of these PhD students, I share my office with a few of them. Basically it's massively advancing this kind of slightly obscure field of probability kind of in research, which may or may not be useful. So yes, you get this odd effect; do I think it would be good or bad? Yes, I mean of course it's good if it's well thought through because we can start putting, making money and places available for stuff that can be useful but then again you can get these sort of quirks that maybe aren't useful and you can shut down areas just by accident.

SH: You said it could go 'either way' - i.e. positive or negative - for PhDs. Do you have any evidence that it is heading in one direction or the other at the moment?

George: I mean Imperial is an odd place to kind of be at because it's almost devoid of culture or interaction between the students, there isn't really any kind of culture. So, it feels like a sort of slightly faceless corporate place, which is maybe unfair because all the people can't be like that. I don't know. Yes, you've got all these people coming in to do these financial maths PhDs in the sort of, I don't know, blue shirts and treating it very much like an MBA or a -- and less like, less maybe pursuit of academia. I don't really know which way it's going.

SH: Can you tell me your reasons for doing a STEM PhD?

George: Right. I don't know, it was kind of, well because I came here and did my undergraduate masters degree here and that was all part of the kind of adolescent desire for truth and -- and kind of come to London and seek fortune and glory and then somewhere along the way, I don't know, I kind of lost sight of what I was looking for. Maybe I found it wasn't there or something. I just sort of came to the end of my undergraduate and realised I didn't want to do the kind of science I thought I wanted to do when I started, I didn't really know what I wanted to do. So, I went round and started speaking to people who I remembered in the maths department and the physics department who were doing theoretical physics that wasn't streaming theory, it was all sort of stuff I

didn't want to go in to. Then I met the supervisor and I got on really well with him so we were chatting for hours and I thought this sounds really fun, I'll see if I can get some funding to do this, that sounds great. So yes, I just...

SH: Was your study from undergraduate, Masters to PhD continuous?

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George: Yes, there weren't any gaps, I've been here for seven years now, so. Yes, so it was, the reason I ended up on my PhD was partly not knowing what to do and then partly this opportunity appearing that I just out of just kind of joyfulness because I thought that sounds like it would be great, it sounds fun, it sounds like I'd really enjoy that. So, that's how I ended up doing my PhD, not with any kind of, I didn't get into it with a goal, I didn't even get into it on a particular project but more from a good relationship in an area I thought was interesting. So, just being a bit lost and --.

SH: As you continue with your research what keeps you motivated?

George: You get a lot of freedom just to go through the horror of being a PhD student. I don't know because quite a lot of my friends are either on anti-depressants or they've quit and you, being a PhD student you go through these really low periods. I'm not sure I'd ever actually, I don't think I could honestly recommend being a PhD student to somebody, I don't think I could ever advise that to someone as a good choice. I mean I could tell them not to but I don't think I'd ever actively encourage someone to do it if they were unsure.

SH: What makes you say that?

George: I came in slightly unfocussed not really knowing what to do and so I think I wasted maybe the first six months to a year with trying to work out if I really wanted to do this and I know people that come in and they do a bit of labour, who are a bit more focussed about what it is they want to do I think get a lot more out of it. With a PhD you get out what you put in because you are sort of working for yourselves. If you're feeling a bit miserable, like you're not doing much, well the only way to deal with that is to do some of the stuff. So yes, because it can be quite lonely and an odd experience, particularly in the maths department in Imperial. Why did I keep going? There was

enough fun there, enough good times and then I still sort of like, I do like what I do but I think maybe I'm not cut out to be an academic after all.

SH: How important is the achievement of the qualification?

George: To me it's not, yes it doesn't really feature in my mind because I will be a doctor, I will have this PhD. I don't know, I've never found a good thing so far in my life where everything's been pretty much an anti-climax, when you did your GCSEs and it was like, is that it? Then my A levels and my degree and now I take my PhD and I know afterwards I'll go, oh that was,

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I'll probably feel more with my PhD a sense of satisfaction in I've produced a work but I don't, it's not, I don't see it dangling there, this golden carrot that I'm chasing after. I didn't join with a sort of goal, I'm not, I haven't been very goal orientated about it, so that hasn't been my experience but maybe I'm probably not a good example. I didn't come in to my PhD in a sort of knowledge economy approach about what I wanted out of a PhD because I didn't want anything. I didn't come in with desires, I didn't come in with goals but I mean it's probably a lot better to do so, to come in with either a desire for the subject area so you'll get into the academic side a lot more, what is the, a desire for a certain kind of training.

SH: Based on your own experiences, do you think many PhD students do come into it with 'goals'?

George: Most of the physicists that I know got in and they're pretty committed to being academics or getting the hell out of anything ever to do with their, they're most committed to carrying on into the career of physics and that's... In the maths department the people I know, I'm not sure how many people I know, because I share my office with a lot of financial mathematicians a lot of them have come in to get a certain kind of training because they're looking to work in investment banks. I don't know how representative that is. Yes, so far it's kind of split by area. Some areas are very focused on, yes, let's keep going; some are somehow training grounds for industry in a way, yes.

SH: How important is a consideration of the type of knowledge you will produce from the PhD: whether it is valuable for being novel, for knowledges' sake, or whether there is some seen application, for example?

George: I don't think about utility at all. I'm slightly divorced from the utility of everything anyway because I'm, so really I do mathematical physics so everything is fairly abstract so yes, I'm so far away from something I can see as an application so I'm not focused on it. I do it I suppose for my own interest and because it sort of fits in with the context of what's, it kind of fits in with some other people to work. We're like, I think I'm too far away to be able to see an application, yes, so I think, I suppose it's mostly for my own pleasure or it's mostly because it's fun or pretty.

SH: Did you have any expectations about what the PhD would like and how has lived experienced played out in comparison?

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George: What were my, no, it's not what I expected it to be but that's, I'm not sure if that's because of the PhD so much as about me, I think.

SH: How has it not been what you expected?

George: I suppose I'd always thought I'd maintained my sort of obsession, interest and definitely have been producing more work and have been more interested and more motivated and more keen to carry on in academia; but I've learnt a lot about myself and I'm not the person I thought I was, it's not the PhD because I think blaming the PhD I don't think is the right way of looking at it. Or the PhD is a fairly kind of neutral institution because it's so, aside from the kind of theoretical side where you don't have a lab or a brief to work with, it's so much what you make it yourself. Yes, I was expecting a different experience. I wasn't, yes I wasn't really aware of the kind of how isolating it would be at times and how kind of shitty you can feel and yes, I was expecting a different experience. Yes, I think I was expecting a different social experience because so some people are very lucky in that they have a group of people working in that area with them and so they've got a lot of people to talk to about their work. Unfortunately in my group, in my department there is no one for me to talk to so I'm quite isolated. So, that can happen, if that does happen that can obviously be a bit of a problem. That drove some people that happened to a bit nuts and that's why they ended up quitting. Yes.

SH: How much academic freedom have you had in the PhD?

George: More; I've had a lot of freedom. That's been great, a chance to kind of lose yourself and find yourself and then struggle on with things and my supervisor's been great because he was there for me always. There's no kind of, I've never had any trouble getting a lot of face time and working things through with my supervisor. So yes, that's one of the, I think, the great joys of being a PhD student rather being an academic is that the, is the freedom you have to either work really late or not at all.

SH: Do you think that atmosphere of freedom is an essential part of the PhD?

George: Yes. At least part of what you're needing to learn as a PhD student is how to do research and the non-linear way that works. So, you've got this, I guess it's similar to my brother is a musician in terms of that level of self-motivation, there's no one telling you to get up in the morning, there's no one telling you where you should be taking your research and what you should be doing.

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You find in these, it's sort of a test to see can you self-motivate and are you passionate enough about this to sort of, do you have this kind of odd drive? Are you a broken person that will just stay in the department all the time, ignore your family and yes, so that kind of freedom to, yes, I don't know, stare into the abyss and kind of face down your demons and work out if you are the kind of person that can do this or not. Yes, you do need I think quite a lot of freedom to work some things out by yourself and what your relationship to that kind of work is. Yes.

SH: Also in the questionnaire, I asked whether you thought your PhD was connected to the wider world. Here you said no, and that what you were doing was 'pretty abstract'. Are you still in agreement with this response?

George: Yes I think so. No, it probably, I think it actually has more applications now, I will admit it or willing to look in to but yes, I'm sure if I just look around a little bit it probably has a whole tonne of applications but not that I'm strictly aware of and not that I'm aware of while I'm doing the work.

SH: So, thoughts of potential applications don't factor in as a motivation for you?

George: Yes, I'm not in a kind of area where I can start making a spinoff company from the work I'm doing or where I can find an application where I can say this could be really useful for medical imaging, this could be really useful for building in a tender; I'm unfortunately not that kind of physicist. I'm not in that kind of area. So, yes I'm not one of those people well poised for the spinoff company side of Imperial. Sure as an undergraduate in our final year we did this sort of research interface, some course about, and part of that was about designing a product, bringing a product to market, how do you go about creating a spinoff company? It's pretty interesting and that's cool but it's unfortunately just not anything in my work like that, it's not something I could remotely get to in what I'm doing.

SH: And due to the nature of your area, would say people are understanding that you are unlikely to have an idea to apply or 'spin-out'?

George: Yes, yes, unfortunately I mean that's kind of, I'm not applicable to that so I'm not too useful for you in answering those kind of questions.

SH: What do you think your PhD is preparing you for?

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George: I think it was supposed to be preparing me for maybe a post-doc position for carrying on in academia but in fact I'm not sure I'm going to go down that road. So, in fact I'm highly trained to do nothing.

SH: Do you feel as though your skills are transferable to areas outside academia?

George: Yes, well I'm starting to look for what those other options are. I mean yes, I'm good at maths and I learn very quickly and I like modelling things so, yes I'm not specifically skilled up for any kind of job but I'm not scared of learning any kind of, anything really basically. It's made me slightly fearless and confident in my ability to learn something quickly but I'm not, I don't feel specifically trained for anything.

SH: Do you still wish to pursue a career involving research?

George: I went to this careers fair yesterday, yesterday evening and it was banking and finance careers, which is basically what you're expected to go into. You're kind of presented as a numerate PhD, as a physicist or as a mathematician so say you can code, you can do maths, fine so you're obviously going to work for an investment bank. It's sort of expected that you'll go and work, if you're not extremely applied in which case there's industrial R&D you can do and then the more theoretical people that say right, finance and that's the sort of, so it's academics or finance, you've got this kind of, it's that sort of, that's the sort of traditional narrative at the moment, or that's the dominant narrative at the moment. In all of these identical corporate institutions you're expected to be a coding monkey and I'm not sure that, I mean the trouble is the PhD, doing a PhD has made me want, realise that I need some level of kind of mathematical creativity to express myself a bit and if I still need to be able to do some kind of research and thinking I think that's part of how I self identify. I need this kind of creative outlet as well as some others. I think it's my need for others that makes me think I can't stay in academia and it's my need for some creative outlet at work that makes me nervous about this kind of study, this certain kind of identikit corporate institution. Yes, when I was going around looking there I wasn't, I didn't quite find what I was looking for in terms of I'm not sure how much creativity they actually are allowed.

SH: My next question is, imagine you have to explain to someone who has no knowledge or understanding of what a PhD was, what you are doing and why, why you are doing it - but you

also have to convey this without drawing on the notion of a 'PhD' or a 'STEM' subject - how would you explain to them, what you do and why you are doing it – in the most simple terms?

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George: I suppose if I was being extremely honest I'd tell them, I'd say I'm very confused in terms of trying to justify a PhD to an extent or doing a PhD. Doing a PhD, what do you do day to day? Well, you're trying to learn how to do research, I'm not really sure...

SH: What if they asked you why you were doing it?

George: In my area there is no specific point, it's blue sky thinking that because you don't know what you're going to get out of it so you don't go in with a goal or a purpose. You know that there

are some areas that are interesting and some others that may be good to solve and maybe there are some areas to do research in but it, because it's so open-ended you don't know what you're going to get. So, yes you don't have a goal as such. You could get back something really amazing and interesting or you could just get a pile of rubbish and then you'd scrap that and you'd carry on.

SH: If I were to ask a member of senior management at Imperial, of the purpose and status of STEM PhDs, what do you think they would say?

George: The primary purpose of the PhD population is for producing the next generation of researchers and they're also here doing research and aiding research themselves. A lot of them will have been recruited on to projects to help analyse data and help start doing some useful research rather than aimless and insane research, what I'm doing. So yes, they, the principle role is this combination of becoming the next generation of researchers and continuing the research and helping the research that's currently going on at Imperial. I suppose well do they have any secondary roles and most of the PhD population do, I suppose they start to produce research themselves. They can, because they're right at the beginning they make a better place to go off in to industry or to start spinoff companies. They're also probably a useful tool in terms of networking between groups at Imperial. So, if you're trying to foster closer connections between slightly disparate groups, you're trying to encourage cooperation, you can start getting them to share PhD students so they're a way of creating joint projects and joint ventures. Yes, so then how does that make me feel about what I think from the inside of a PhD, what a PhD is for? What it is?

SH: If I were to ask a member of the current UK government, what they thought the purpose and status of STEM PhDs was, how do you think they would answer the question?

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George: I don't think it would be significantly different to the managerial position. I would think they probably wouldn't be as directly concerned with say communication between the groups. So they'd, I mean they might consider that but certainly not that they'd be aware of them, we're training the next generation of scientists and researchers and highly skilled people for tech jobs. The other consideration they might have is maybe as ambassadors for education in the UK they would be aware that these people are going to scatter to the four winds in some cases, so they'll start up new companies some of them, some of them will go and be involved in industry and then some of them will go to universities around the world. I think maybe the Government would have an idea of

their role as ambassadors of British education. I think it's the only, I would imagine that's the only, yes, that's the only consideration they'd have, that they might be aware of that.

SH: Ok. Now I'd like to ask a bit about how your research, your thinking about your research, has developed since the beginning? I'm particularly interested in the major influences on you, both internal and external to the university.

George: In terms of direction of my research, well there aren't any post-docs working where I am because in my kind of area, they're only PhD students, just me and my supervisor. I did eventually find a couple of people that talk my language but our research is so far apart. We can still talk to each other vaguely about what we do but they don't affect where my research is going and otherwise I had maybe some advice from one other professor who used to work in the same areas as my supervisor. That didn't really affect the direction of my research because I was doing just a whole bunch of learning and then I had a couple of problems to solve, I'm now looking for some other problems to solve. In terms of my experience of PhDs and education in general, I mean it is a very politicised issue. The experience of a PhD has obviously changed while I've been going through and I've gone through the highs and lows and also seen my dear friends fall by the wayside, so I'm aware of maybe the faults of specifically doing a PhD at the Imperial College in the physics and maths department. I'm aware of the good points and the bad points there, but not maybe PhDs in general in terms of education and its wider context; then yes, it is a very politicised issue. I've become increasingly aware of that and I'm...

SH: Could you please expand on what you mean when you say it is a 'very politicised issue'.

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George: Yes, the student protests, which I was a lot more aware of than say the top-up fees.

So, as an undergraduate I was somehow, education changed just before I went to university so I had to pay some fees but then I was before the next round of raising fees. I was aware this was happening but not really engaged with the issue, but while doing a PhD it affords you time to also get a good knowledge of the culture in London as well as when your research is stacking up and also we're well informed about everything that you can become well informed about. A lot of my friends yes, I suppose are involved in political activism, so yes I've become more aware of the context of what maybe education might mean or certainly in terms of funding and the economy, what is an economy and what's it for?

SH: Do these reflections feed into your PhD research?

George: It feels like I think the way I relate to my PhD and the speed with which I want to finish it. I was aware that I could go and hide in my PhD for a while because I started my PhD just before the likes of the Lehman Brothers collapse. So, some people that went straight into finance were fired pretty quickly and so it was like, okay, I can definitely hide in my PhD; it's a very secure place to be. Now that I've had to start coming out of it I'm, yes, I'm sort of reengaging. Yes, it's making me think about how I want to spend the last year of my PhD in terms of are there some projects I want to look at that will maybe give me an edge, a certain program language or maybe, or might be slightly connected with something I want to do outside, or not. It's kind of puzzling and it's certainly made me feel a lot more confused about what I want to do afterwards because you want to make some kind of ethical and moral choice about what you want to do afterwards. If you can't do something that's pure and sane in academia then what is it you want to do and then how can you, can I -- from the last year of PhD -- that or not? Yes, so it's thrown up a whole bunch of questions on how I finish my time but I don't know, it hasn't affected my research yet.

SH: Thanks. How you would define scientific innovation?

George: It's a terrifying thing to try and define. I don't think I could, beyond the sort of kind of vacuous and obvious statement of...

SH: What kind of criteria would apply when trying to decide whether a piece of research or knowledge should be labelled 'innovative'?

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George: Is this research innovative or is it not, is it just boring? I suppose a novelty in a way, some kind of a novel use of a technique. It's a little hard, I mean to get at. When you're listening to a piece of music and it makes you laugh and smile because you think that was really funny and clever, I wasn't expecting that; so maybe sometimes similarly when you're, I don't know, flicking through some research you think yes, this is good, this is solid, yes absolutely. So that's all good research but maybe, and that's maybe, some of that's innovative. Yes, just maybe using,

getting something slightly unexpected or using a technique, like oh yes, you could use that there, that's really interesting.

SH: So, in terms of your definition of scientific innovation, is it something that, as a PhD student, you see yourself contributing to?

George: Not really. A lot of PhD work is: 'nobody's cleaned that corner yet, go and clean it'.

SH: Do you feel encouragement to be innovative?

George: In a way it is quite, you're having to learn a lot so you're having to learn your subject area and learn how to do research. I spent a lot of time learning, which was fine and then I was supposed to do this quick-learning project and it was doing a calculation that somebody at Imperial had done, so it was this paper that they'd published and they'd analysed a model in a certain way and I could analyse it in a different way. It was supposed to be just a quick project to check that I'd learnt how to do what I thought I'd learnt how to do. Then I found out that this person had done the analysis wrong, so what was supposed to be a quick calculation before I went on to do something creative, that seems to happen in PhDs is your little toy project explodes and it's a lot more difficult than you thought it was going to be. I had to very carefully do the calculation properly because I found that somebody had done it wrong, so I don't know if that was, what I was doing was innovative or I mean I was checking up on someone and was that quite conservative? I'm not quite sure how to conceive of it, but that's what happened. Having done that, but then I've now got the freedom to do a lot of other things like I suppose the last little thing I did was an idea about how buses come together, why do they come in twos and threes? It started with a conversation in a pub with a friend of mine and we've sort of built up this theory and it works. I don't think anyone's done that and that's just a bit, that's, the chance to do something silly and fun like that is innovative. Maybe that's not conservative, that's probably quite creative. Yes, so I think yes, there are aspects of a PhD that are, and I think some peoples' are probably a lot more conservative.

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SH: To move to my final questions, in the UK, there's been a real push to get more young people to study STEM subjects. Do you think this policy is a good one, and why?

George: Yes I think it is. We're surrounded by baffling technology for a start and so having any kind of grasp of the workings of these magic black boxes has got to be a good thing; partly because you can stop people bullshitting you about things. Studying maths and science is also, it's enriched I think my understanding of life as much as some of the best literature I've read. It's provided me, in fact more so, it's provided me with these metaphors of understanding, like how things relate to one another and so people are making these arguments about things you can call it bullshit or agree and say no, it's a different way of conceiving it. It has been really good in providing you with these metaphors. You don't even have to be doing maths but if you've done, you're aware of it then yes, you've got this much richer understanding. You've kind of got a duty now that you've pushed on so much in an attempt to appreciate or understand some of the knowledge gained since we were, I don't know, running around in animal skins. But yes it has just been useful in terms of understanding the world, understanding peoples' arguments, providing you with these rich metaphors. Yes, you can relate to the crazy technology we have now a lot better I think, maybe people can't lie to you as easily. Then also it's any kind of appreciation in a statistic light, particularly I suppose in times of economic prosperity and then also trying to think clearly about what that means and what to do about that, then having looked at maths and science and engineering is pretty useful. It's pretty useful in terms of trying to decode what some people are saying about say climate change and these are other big problems that if you don't have some kind of studying or understanding of science and maths then you have literally no idea what to think or believe. What else is it useful for? Also what are you going to do in this country? Work in a call centre? We don't have mines anymore; we don't have industry anymore, this has all been destroyed rightly or wrongly. It's basically we don't have that kind of economy anymore, which just yes, okay so maybe you could get into a discussion about globalisation and the moving around of industries over the world but yes, what are you going to do here? There's not that many other options. Yes, there's a whole bunch of service industry stuff but I mean the NHS is the biggest employer but you're going to have to do some science and medicine to get into that. What are you going to do in a country with no, with almost no actual production? So, there's a whole bunch of reasons I think it's really good; but it's also good for its own sake.

SH: And hypothetically, if we have more young people interested in STEM subjects, taking them up at GCSE and A-Level, undergraduate level, then there will be many more for whom

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the STEM PhD becomes a feasible option. Do you think we should be looking to expand the STEM PhD population?

George: There is always more research to do, so it can only be a good thing to add to the sum total of human knowledge. Would it be good to have a million doctors walking around? Or doctors of different subjects? Yes, I think it would be. You do reach this critical mass of there's so many people can do so many different things you, there are more people I suppose able to start up and do odd things. Yes, I guess the bigger, the more skills people have the more things that they can do, so yes I think that can probably only be a good thing. I think that the discipline of thought that you acquire doing it just helps you with all your other subjects, so if you were studying stem subjects at A level then I think it actually helps you with the others or doing anything else.

SH: And what about the person? Are there any characteristics that you think are important - in addition to the prerequisite academic qualifications - for undertaking the STEM PhD?

George: Do you need to be a slightly autistic geek to do a STEM PhD? Maybe you probably do. I think coming in with some kind of passion focus is pretty important. I wish I had actually; maybe I should've taken a year out and come in a bit with more idea about what I wanted to do. I mean falling into a PhD in a slightly clueless way wasn't maybe the best thing to do, so yes, I'm all for more PhD students if that's, that is definitely what they want to be doing. Doing it in a slightly thoughtless way isn't very helpful for anyone, certainly not for the person doing the PhD.

SH: Ok. So my closing question is, if we think back to the concept of the 'knowledge economy', is it in any way an inspiring or motivating idea for you?

George: For me personally no but that's my context. I think maybe if I'd come in differently and I'd thought about things differently at the start, come in with some kind of focus but I didn't so I don't.

SH: That's all my questions; thank you very much for your time.

b) The UK knowledge economy and STEM PhDs interview 12: Will

Interview length: 1 hour 4 minutes

[1]

SH: So last year, when asked about the knowledge economy in the questionnaire, you said 'yes' to having heard of it, and defined it as: 'a marketplace of intellectual materials'. One year on, are you still happy with this definition?

Will: Yes. I suppose, yes, I'm probably happy with that.

SH: Is it a term you have heard in the past year?

Will: I think I heard it more two or three years ago. I believe there was some bizarre notion that in order to compete with countries that had more people in them, you would have to spend more time on education and knowledge as opposed to sheer brute force. So there was that discussion. I haven't heard much about the rise of China lately, personally.

SH: I also asked whether you thought the knowledge economy was a positive, negative or neutral shift for the university, and here you said 'neutral', giving the reason that: 'Britain cannot compete through simple industry, given the rise of China and India. The only way to profit from ideas is to create students who are independent thinkers and to generate new ideas. On the flip side, tying academia to industry could destroy academia in the making - focusing on that which is immediately useable and spending a large amount of time fighting for funding; not what academia aspires to'. One year on, are you still happy with this answer?

[2]

Will: Yes.

SH: In terms of it being a situation of two 'flip-sides' - do you see evidence that it is going more in one way or the other?

Will: I think it's interesting. I'm industrially sponsored, so I have a foot in both camps. What I have seen - well, it's interesting: my supervisor was recently awarded a massive EPSRC grant, so he fought for a concept, and now he has the time and money to live it out and make that happen. He has asked my company for suggestions. So I think in that case it can be a healthy balance between those two. In general what I've seen people doing is, particularly in my department - I think it's not

true in all - is that people do just jump from one publication to the next. So what I would say from what I've seen is that people don't ask hard questions. They just publish what they can. So my supervisor's position is quite nice, because he's asking big questions and he has the money to do so. so in terms of what my company - if my company provides suggestions of what to research, most of the time I think my supervisor would say that they're too narrow, and he will try and broaden them out. His argument is he likes to stay about five years ahead of industry, and there is a rather interesting idea that he is bound by industry, but he's not, and it is a balancing act. Whereas I've seen, if I actually look around the department that I'm in, I do find it quite funny, because we had like a seminar in my department: at the end of it they said, "Does anybody have an industrial application of this?" They're actually looking for problems. They're not going to find any. I know what their research is; nobody actually cares. Or there's only about one person doing it, among 12 PhD students. There's only one person doing research that I think should ever see the light of day, that we should care about. So I've been attempting - and this is quite funny: I've attempted to arrange a consultancy meeting - between my company and this individual - though Imperial consultants. That took months. It didn't really go anywhere. So eventually I said, "Great. I will take the PhD student into the company," because my company is actually quite good at that now. It does invite academics in to tell them what they're doing. And I attended one of these, and it was very funny to realise that the academic in question - he was trying to solve a hard problem, but he had no industrial code to work on. What he was looking at was 10 years out of date, and he had some vague idea of how it worked. He was asking for industry to help him, and they just dismissed him out of hand because what he's doing is pointless. He's cooked it up. So that was a waste of time. So in my talk, this PhD student came up, presented this very, very good research that I know the company would benefit from, but the company is not ready to benefit from it. It doesn't do enough analysis. Industry doesn't think hard enough to be able to take in this guy's research,

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although I know we should. Amusingly, because the company won't take in this guy's research, it's going to fall to me. So they aren't prepared to pay the student the money, because the fees are quite large, but we still have the problems. But they're not prepared to think broadly enough to solve them. Anyway, sorry, to babble on. But, so, yes, what I currently see: my company is good. It is prepared to invest in research. It looks at the States and how large companies interact with the Ivy League- you know, the big hitters, and they are envious of that relationship. So they do want to head down that route but it will take time. That's why they've invested in PhD students. But on the flip side, the academics - this year I've been to academic conferences and technical user conferences,

and the difficulties are wonderfully enormous. So I presented, this week I went to two technical conferences: I won Best Paper award for something that is academically trivial, and there's a shed load of money that goes with those. You go to the academic conference: nobody really cares about making their work see the light of day. Basically this PhD student who we took into the company, he should have patented his work. He's not going to. That's not his interest. And looking at his papers he's now publishing, they're not important. He's not actually solving the problems; he's just publishing stuff. So the work is good, but he's not getting his hands dirty enough to make it happen, and they have no interest in making it happen. So despite the links between the two, I don't see any real attempts to bridge those gaps. I think from a publishing angle, as the funding works, people need to publish more frequently, they will ask more dull questions, and to be honest with you, what I've seen people do is they will look in the publishing history and they will learn from the history of publishing what is publishable. They don't actually solve problems. They just publish. So I think the quality of work will go downhill. Industry could step in, and the universities will happily take their cash, and that actually might be beneficial, because industry might demand, 'We want you to solve these problems. Off you go.' So that can be a positive thing. Certainly in these cases it sounds like industry - I mean, I personally think, as I said, tying the universities' research to industry is not healthy. For example, so I sat down with my seniors and said, 'Here's the research I've done so far, or plan to do next.' Unfortunately, it took them less than five minutes to take the general research themes, and they changed it into what had to happen next week. So I got absolutely nothing. I'm quite lucky, though: I basically dictate my own research, because they don't actually know what's good for them. They are so customer- driven, they face so many daily issues, even if there are hard questions going on, people just make do. Is the company prepared to invest in a long-term plan saying that this is going to hit us in a year's time, two years' time? Because that's the real problem. Because if you look at consumer industry and you realise how the marketing messages change, there'll be a point in time where bandwidth is everything, as soon as mobile devices - you know, there's no problem with speed. As soon as you have enough data coming through to your home or your device, the game will change

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to something else. And it will be sudden. The interesting thing is that the moment there's a change in marketing message about what's good, there's going to have to have been a shit load of research done, that could take decades, to then answer the next question. So you really can't be tying academia to these questions, because industry, it's so short-term, it's ludicrously short-term. So, yes, I think it's - my company certainly does - the fact that we had about 20 people attending an

academics' lecture is a good sign, so they are wishing to expand in that area. We have a lot more interns and involvement with the university from a recruitment angle. So we kind of care, but I don't think - the company would never assume - they would not expect that any PhD student or any academic is doing anything useful. My supervisor deliberately places his work five years ahead, so by definition, it's not useful. So by construct, the two worlds are not designed to meet, because the currency is different. In the academic world the currency is papers. I've seen some of the PhD students' code. You wouldn't ever hire a PhD student because they can code, because they can't.. They don't work on big projects. They don't really engage with other people. They only work together, because of these papers. If you go into industry, of course you need to get stuff done. You don't care about publishing; you don't care about papers. So I think the value system is so enormously different that you're looking at - you know, it's a very hard gap to bridge. Certainly from the academic field, there were certain research areas that literally looked like a bunch of academics had got together to pretend there was a problem. That's extremely common. So whether that is or isn't a good thing, I'm not sure, but there is a tie there. I work in the electrical engineering department, so they are tied to industry, but still quite separate. So, yes, it's a very interesting balancing act. Do I think it's going to get worse or better? I think one of the reasons, every time I present to my department, my research, I am hopefully increasing people's awareness of what I do, which is basically the same as what my company cares about. So there is a hope that people will look into the issues that the company cares about. One of the big stumbling blocks is the technology, so in electrical engineering they normally use things called FPGAs, because that's all they're kind of taught. My company literally makes chips. Well, it designs chips, and they're different enough worlds so it actually changes the game. So actually, I can understand why the universities don't focus on some of these problems, which is fine, but it's interesting the one that - you know, the university doesn't have - and actually, this is another point: the university does not have access to the latest industry-standard tools. Which, I'm not sure why. If there's a new industry tool, you would think possibly that they would want researchers to have tool As a research student, you don't work with these tools. The companies that I've spoken to, they would rather make money, so they would prioritise paying customers, and that's what they will do first. So the universities, they don't have the latest tools; they don't have support for the latest tools. So their experiments are probably more painful to perform than they would have been in industry, and

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they're involved in research that is not obviously relevant. The fact that a PhD student spends a year possibly finding a problem I find funny. I go into my company: there are problems every single day.

But yet you have PhD students finding problems. So, I mean, the two places are obviously very different. They could benefit far more from each other. But yes, these are very, very different worlds.

SH: For the PhD student, you also said that the knowledge economy was a positive shift, because: 'currently, PhD students measure their value by publications; adding industry requirements could broaden research'. Are you still in agreement with this answer?

Will: Yes.

SH: Can you tell me your reasons for doing a STEM PhD?

Will: So, when I worked in a company, I added value by looking at the code base and doing better than it. So my reference point was just making things better, but then my line of work kind of dried up, so I left. I worked in the City for two years, which has other interesting problems. It doesn't suffer from being slow. That's one thing it doesn't suffer from. But I got bored again, and my old company approached me and said, 'Do you want to come back?' and I said I was bored. So that's when we cooked up this PhD business. So the reason why I think it's useful is, so whereas before I was just improving the code: I didn't read papers; I didn't do things on an international level; I didn't do proper research. So doing this, I get to take industry-standard problems and I have the ability, I have access to the latest industry tools. I have access to application engineers who support those tools, so if I get stuck I can just ask those people. But I can use those tools and that support on the industry-standard research that I'm now doing, and that in my opinion is the best of both worlds, because you want to take - I come to the university about one and a half days a week, and even though most of that time I spend fending off work emails, I'm still somewhere else, and I can ask the harder questions that you don't have time to do on a daily basis. And I do the papers and do the research. But at the end of the research there's a really nice moment where I send off the publication, but whether it comes back as an 'accepted' or not is kind of secondary, because all the research I do I use in my company. I get my own feedback loops, and that's definitely what no PhD student normally has. So I do write code that is delivered, and I think PhD students suffer horrendously from no feedback. If you get published, that's not the feedback loop. The feedback loop is to do with your work. If you have an idea, you want to see somebody use it. I don't think that's very far-fetched, but I know it's quite unlikely. So at the moment, all of my research is used

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on a daily basis, and it involves - so I've dropped in some code, and people use it in bizarre new ways, and they'll come back to me with improvements: 'Can you do this? Can you do that?' So that evolves. Obviously if you just publish a paper, you don't normally - people may cite it, but the feedback loop is pitiful, and it's not very lively, and that's one thing I must say. Coming to university, these issues, in my department, they are in isolation. There's no energy. Despite everything, if I go to work, yes, most people might be quite stupid, but there is an energy about getting stuff done, whereas coming here, there's not as much intellectual energy as what I was expecting. But it's still highly valuable to have the time out and actually think properly about some of the hardest problems that you kind of face but then you just try and ignore. So, yes, it's extremely valuable, and I can't think of a better position - because also, it's not as if I did a degree and then I applied to a company for sponsorship. I'm not one of those people. I have been in industry for a while, and so I have people that work for me in the company doing the dull work, to allow me to go and do this. So I'm extremely lucky. I couldn't think of a better situation. Although it's a lot of work, if it can be managed properly then it's ideal, because I think both sort of places I work in have serious pitfalls, and they have serious advantages, so it's about how I can make the most of those two.

SH: How important is the motivation of getting the qualification of the PhD?

Will: When I worked for my first company, my boss said to me he didn't value PhD students. He preferred people with degrees. PhD students have buried themselves in one thing for too long, and they have lost energy by that point. I'm not sure how common it is, but reading some of the stuff I read, there's, like, second-year blues or something. PhD students, it is solitary - I mean, I [unclear 0:19:48.7] because people say it's solitary, it's a very selfish thing you want to do. And again, that's a problem, because it points to the fact that you have no feedback. It's selfish because all you actually get, all you're actually looking for is your name in various forms of publications. That's all you get. You don't get the satisfaction of having done anything. Nothing will come out of your work. Hopefully somebody might pick it up. So there's very bad feedback, and because there's bad feedback, I suppose it is extremely - I mean, the research - it is selfish. I don't really - nobody would do that for some grand, higher purpose, so that can't be why people do PhDs. I did meet one guy who did a PhD because he went into industry, he looked at it, and thought, 'This is shockingly tedious,' and so by that sheer boredom, he did a PhD. I think I did the PhD to do something harder,

a lot harder. As for, the qualification, as I was saying, my first boss didn't value them because they were too narrow. I employ a PhD student now. It's very hard to make generalisations, but, yes, it's going to take time - I employed a Maths PhD student – probably

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a little risky - but it's going to take time to shake him out of what he was, and I would possibly agree - I would find it tricky, I must say, to have embarked on a PhD for its own interest. The risks are extremely high. If you do your PhD, get the qualification and then get employed, I mean, to be honest, if you compare, from my company, a graduate going into the company, three or four years hence, where are they? What have they learnt? What have they done? How much do they get paid? Versus what the PhD student will come in on - assuming the fact that the PhD student will never go into a job that uses their PhD, it's a rather interesting question: whether you will engage with it. So I think nowadays in particular, I'm guessing most PhD students will now before embark on it, they will really ponder about use. I think it's a very impressive thing - I don't know who does this, but if you can walk - depending on the problems you choose - you could walk into an industry having done your PhD with something that you can add as value. I don't know how common that mentality is. That's something you would have to do during your PhD. You'd have to work out, 'Am I solving something that people will actually care about? Can I then go and pitch this to people?' That's certainly not the impression I get amongst PhD students.

SH: As you continue with your research what keeps you motivated?

Will: Because I have decent feedback loops. Publishing: nice, but I am solving my company's problems by doing what I do, and that's the reason why I keep going.

SH: Did you have any expectations about what the PhD would like and how has lived experienced played out in comparison?

Will: To be honest, it's a lot easier. I'm not sure if it's true, it's a bit hard to pitch. So the amount of work I do, the amount of intellectual problems I solve, I'm getting away with quite a lot. I don't know whether my supervisor is hiding the truth of where I should be, or whether - well, I actually can be at it - I've been in the industry for a while; I've proved already a lot of knowledge, and in some ways I'm just now formalising tricks and I was getting my IP developed before. So maybe my life's a little bit easier. But I certainly don't think it's as hard as I was expecting. So, yes, it's fairly

lax. Yes, I think, to be honest with you, I think it's a bit of a waste. To go into the department, see a bunch of PhD students working on things that will never see the light of day, extremely clever, plodding along quite happily; there's no real rush. There might be some deadline suddenly appear. The deadline passes, you submit something, you don't really feel happy because haven't really done anything - so in general it's - the only thing I find shocking is for those other PhD students, who are solving hard problems, to be paid next to nothing to do so is just weird. If I

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go to the company, there are idiots making more money than they are. What was that thing about, 'You make more money on a Tesco checkout than you do marking academic papers'? I mean, that's a strange world. That's a very strange world. So, yes, it's odd. Would I like to employ people in my department? Yes and no. That's quite an interesting question, actually.

SH: In the questionnaire, I also asked whether you thought you PhD was connected to the wider world - you said yes. Is your perception of this connection important to you?

Will: Yes, I think it's very important. What I find scary - I spoke to an Oxford historian, and he complained about having to fill in really hideous forms like 'Why is my research relevant to society?' and he really hated that stuff. But I kind of disagree. I think the way it's approached is quite patronising, but I think that you do have a serious duty. So what I've found quite scary, I've met people before, so they're academics who hate teaching. They love research; they hate teaching. I think that's incredibly selfish. They are fortunate enough - and this is the other thing, is that it's not - they are very fortunate. They were born with a set of genes; they are blessed with enough brain cells; they are clever enough to be allowed to further their own research interests. But a lot of that is not their own doing. They are lucky. Even your capacity to hard work is actually highly correlated with your birth order. If you're first born, you work harder. So the fact that these people have these jobs, they owe an enormous amount to, basically, their parents and other people, and the society that allows them to function. So the fact that they don't like teaching is really awful, and the fact that they don't want to bind themselves to society is unacceptable. So reading things like, I remember some pure mathematician who works in Manchester somewhere: he does Pure Maths, and he said, 'Oh, yes, my research will go into encryption algorithms for credit cards'. It's complete rubbish. That's, of course, not his interest. That's not why he does this work. But the fact is: if you win more awards and things you get to do less teaching. Which is a tricky one, but I don't appreciate the fact that they aren't linked to society. You have a serious obligation - and also, more amusingly, if you're

going through a recession, and you still have your cushy academic position, is not there going to be a bit of you that says to yourself, 'Surely I should be more useful'. Because the historian, despite everything historians do have a lot to teach us, because if you actually read the newspapers, you'll find that most of the viewpoints are archaic, they're extremely boring, and all that kind of, the immigration stuff, I mean, if you look at the history of the UK, we were more multicultural centuries ago than we are now, so you've got all that kind of stuff. So history can do a lot for you, and this guy has no interest in furthering that viewpoint to society. He just wants to do his research. He's irritated by students, because possibly they want to just get a degree and move on. So, yes, I don't appreciate the level of disconnect. So I do find it interesting that my supervisor

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deliberately pitches his work five years ahead, and I suppose his work, his old work, may filter into usage. I don't know. But he doesn't care about that, and I find that hard to swallow, because that's quite disingenuous, and selfish, and it doesn't feed into the fact that he's fortunate to be where he is. It's tricky.

SH: Is there a tension between the connection with the wider world and scientific principles such as unbiased, objective, 'pure' research?

Will: There definitely is... [pauses, thinking] What my company values, there might be some metrics - like in any organisation there might be things people particularly care about; their customers might care about something else. So they might be disconnected. So I pander to my company's metrics. Do they always translate to - if I wrote a paper and said, 'These are the selling points,' would that translate? Invariably not. And would my company's metrics be shared by other similar companies? Also possibly not. So yes, I would say I'm biased by years of having worked for the company, to know what they actually care about. But also I'm manipulating what they care about. So, yes, there is bias running around, and also my supervisor's biased, how he sees the research field. I mean, he probably would think that there are whole little chunks of research areas that should be culled off because they're a waste of time. I think it's an interesting one, but I would say yes, there is bias. It's not overt, but yes, in essence I am playing off multiple different value systems against each other, and finding some links. What are the obvious value propositions?

SH: What do you think your PhD is preparing you for?

Will: What do I want afterwards? That's an extremely good question. [Thinks.] I would say if my research - well, that's a tricky one. Theoretically my research could allow me to contribute heavily to existing industry tools, so - this is another tricky question. For some people with a certain mentality, my research, and if I was different, I would say, 'Right, I could form a company out of my research.' Is that really far-fetched? It's probably pushing it, but conceptually, it would work. So, yes, at the extreme end it would be forming a company based on the research, although of course there are all these IP issues. The IP I generate now is my company's, so - amusingly, though, they don't really care about some of the IP, inherently. They'll take it. So, anyway, there could be problems there. Otherwise, the exposure to various academics moreover some of the industry contacts, my academic work will bring me into contact with will allow me to - yes, it will certainly open other job opportunities. It's also changed my mentality. So this week I went to two industry conferences. As part of the presentations I gave, by incorporating, not

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directly, but it's based upon my academic research - it's kind of the user end of my research. But that has given me access to far more industry people. The only reason - it was all about a tool that I made my company buy, and the only reason I looked into that tool was because I'd entered this PhD and I was not looking just within the company. I decided to look outside the company. Whether that be academic research or other industry tools - so I'm doing both. And the other industry tools has grown into me attending and pitching at various conferences, so that's the more exciting than that stuff. So I'm not sure what will come out of that, but a simple one would be, if I'm working on the software, it will be embedded in my company's flow, that I will then work on and refine after the PhD is done. So by the time I've finished, there'll be probably about half a dozen people that work for me; I'll have some proof of concepts, through the PhD; and then I'll be in a position to dictate my own terms, my own research terms within the company. So my ideal goal probably is having a research group within the company with a level of autonomy. That's probably the best goal. My supervisor asked me this, and he said, 'You could pitch for a one-to-four ratio, in terms of days.' So he said, I could become some honorary industrial fellow or something, so that would be four days with the company, one day at the university, which is what I do now anyway. So on the flip side, I could do the academic route, so that's four days at the university and one day at the company. To do that, I'd have to publish, obviously, more journal articles, but looking at what the exciting bits of my life currently are, it's not very appealing. So I might go to the former. So definitely, if I can cook up a research group within my company - but obviously it would be very nice to have some contact

with my supervisor to see what he's looking at, stealing his students, you know, all that kind of stuff. That's possibly the most likely stuff.

SH: My next question is, imagine you have to explain to someone who has no knowledge or understanding of what a PhD was, what you are doing and why, why you are doing it - but you also have to convey this without drawing on the notion of a 'PhD' or a 'STEM' subject - how would you explain to them, what you do and why you are doing it – in the most simple terms?

Will: [Thinks.] How I chose my research, by looking at the work I'd done for the company in the past, and what I thought would benefit them. So I looked for inherent intellectually challenging problems my company faced, and will always face, and solving those in such a way that I could drop solutions into industry without any effort on the industry side. So they had to be problems which were publishable, so in an academic weight sense; they would never go away, so industry will always face them to a lesser or greater extent; and they should be solved to a level at which you can deliver them completely and immediately. So those had to be the criteria. I think the last one is particularly non-academic. But those were the criteria for what I looked for to

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research. How I explain my research, what I do is, my company designs graphics chips used in mobile phones. iPhones have graphics chips in them designed by my company. One of the long-standing problems with designing those chips is, from a graphics sense, if you look at various visual --, then there's always some level of distortion. There's some artefacts that you kind of notice, and there is that question of, 'Well, what is too bad, and what is okay?' If you can accept a bit more badness, that actually means you can make a smaller device, because you're doing less calculation. It doesn't have to be as correct. So what my research is is kind of - it's different to what currently happens. In hardware you would tell some tools exactly what you want to build; what my research is, is you say the kind of thing you want to build, but you give it some error tolerance, in your algorithms. So my research is to exploit that error tolerance to minimise hardware costs and power. Power's the big one at the moment. Some people have to charge their phone twice a day, which is just ridiculous. So it's about exploiting, looking at an algorithm, looking at how inaccurate you're allowed to be - so assuming you have those two things, how can you make the smallest hardware possible, for example? So that's the research I do. And those problems, they're not going to go away. They are very, very hard, and I can solve them to a lesser or greater extent, and at the moment I'm able to drop solutions into my company as I solve these issues, so that's what I do.

SH: If I were to ask a member of senior management at Imperial, of the purpose and status of STEM PhDs, what do you think they would say?

Will: That's a really hard question. I have absolutely no idea what my supervisor actually wants. He went into research to add to a body of knowledge, and would the tacky answer be, his PhD students are his army of soldiers doing the same. But the really nasty question is as to whether he sacrifices his students for the cause. It's the core question; it's about, is the research topic the student does - I drive my own topics, because there's no funding body that pays for me. I have no ties. The company pays for everything I do. But if a supervisor owns their PhD student, and they have their own agenda, you're coming into a research theme that may or may not fit the student, then it depends who listens to who. I suppose you're looking for your PhD students to individually provide the answer to a non-trivial incremental gap to a research field, that I suppose ultimately should benefit the field, and hence society at large, I suppose.

SH: If I were to ask a member of the current UK government, what they thought the purpose and status of STEM PhDs was, how do you think they would answer the question?

Will: Oh, dear! [Thinks.] I think it would be interesting to look at how many - in my

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experience, most PhD students don't use their research. Then why would society invest in PhD students? Are there particular reasons? Well, they can work independently. [1.25] Most research - and yes, it's quite interesting, how many generate IP? For Imperial it's quite a different I suppose, but there is obviously Imperial Innovations, so to actually look at the PhD research that goes into something that can be productised - I'm guessing that's kind of a rarity. And given most academics just don't care about productising anything, then claims PhD students contribute economically to society by solving hard problems facing companies- it's probably not just, in my case. So the only reason that a PhD student would be useful is in terms of hopefully producing a better educated workforce, and that's the only reason you'd want to PhDs, other society is just investing a bit more in somebody's education. I don't think claims of solving hard problems and actually making - generating IP, I wouldn't say in my personal opinion that PhD students are a source of IP, because nobody I know cares about that in the slightest. So when I hear the phrase 'knowledge economy' I normally think that it's about people, academics out there, who are generating, solving really hard

problems, and they generate IP, and it's even worse: even if they don't care about starting up their own companies, there's nothing going on unless you fight for it. There's no academics going to companies, saying, 'I've done this research. You might want to give it a go.' That doesn't happen. The company has no time. So the universities might pour out all this good stuff; industry, if they have time to even catch their breath, might want to look at it, but there's nobody - they don't talk enough. So then, yes, I just think PhD students, the time is spent, they might nibble away at some problems, providing an extra bit of knowledge to a research field that may in the course of time, over decades, generate some IP that might be valuable. But that individual themselves is never really encouraged to do so. So, yes, you just get a more educated workforce out of it. But, yes, the idea that a knowledge economy - the idea that people value new ideas and invest time trying to look at research to see, 'How can we use it?', I don't see that happening. I mean, I do it. I really value it. But it's not normal. So the idea that the UK is doing things to foster a knowledge economy: I see absolutely no sign of it.

SH: Ok. Now I'd like to ask a bit about how your research, your thinking about your research, has developed since the beginning? I'm particularly interested in the major influences on you, both internal and external to the university.

Will: Amusingly, I still have IP issues, heading into - I'm coming towards the end of the second year, but yet there is a small bit of fear that my supervisor might have claims to the IP that I've generated. I've submitted two patents so far. So unfortunately, my supervisor, as he will admit, he tweaks the publications. He doesn't get involved in the research. Part of that is because there's

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still fears about who would own that IP. And as I mentioned earlier, my seniors are too - they don't think far ahead enough. So I have solved the problems that I wanted to solve myself, so that my company benefits from what I do but really doesn't understand what I do, so I'm lucky enough to say it's all my direction. But I chose the most relevant problems, I'm looking at the problems in the company that will never go away, and I solve them in a way that they can use immediately, so that's how I chose how to direct my work.

SH: Ok. How you would define scientific innovation?

Will: Innovation? [Thinks.] I suppose scientific innovation, is that anything...? [Pause.] I would probably say if something patentable then it is innovative. That would be my definition. But that's what I value. Patentability – one of those lovely phrases - has to be: inventive, non-trivial, all those things. Inventive, practical, all these kind of things. Scientific: so, yes, in the region of science and technology. Patents to do with that. Anything of that form would be classed as innovative. That would be what I would say.

SH: So, in terms of your definition of scientific innovation, is it something that, as a PhD student, you see yourself contributing to?

Will: I don't see why not. All my research goes into my company, and all of it's patentable, so yes.

SH: To move to my final questions, in the UK, there's been a real push to get more young people to study STEM subjects. Do you think this policy is a good one, and why?

Will: Okay. It was quite weird, we had a female A-level Maths student, A-level student come in. She came for a day and a half, as a work placement, and I went home on the tube and worried about the fact that there weren't enough girls doing engineering work placements, and there was a big push, and actually – I find this quite funny - there was an Ofsted report that was mentioned, that, it said - this is hilarious: 'Despite having had lessons on gender equality, girls are still doing traditional female subjects.' I found that hilarious. It's this idea that if you sit down and tell people, 'Discrimination is wrong,' that you will prevent discrimination. That's hilarious. Which actually asks some really nasty questions: are female jobs inherently female? Or is it societal? I mean it's a fantastic question. Anyway. Are there enough - and this, actually, is another interesting thing. I've got a friend, you may have seen it, who, is are starting up a free school, and so they're

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talking about how you define school, how long should the lessons be: they're trying to be creative about these things. But there was a question, and it said, 'How much time do you spend on the arts and how much time on the sciences?' Somebody said 50-50, and I asked, 'Well, why?' and I didn't get any response. I didn't get - I mean, none of these people - I mean, they have to be pragmatic, but nobody could turn round to me and say, 'If I were to design a curriculum for our children, how would you do it? Which subjects would you choose, and how much time would you spend on each one?' And nobody gave me any answers. I was quite shocked. These are teachers, but they weren't -

you have to ask the question, 'Why do you educate?' They weren't asking those questions. I would love to know what the correct answer is. I've asked lots of people and I've received no answers. If I was to attempt to answer that question, you would have to ask some really nasty --, like, 'Are you truly preparing the workforce?' That's not what education's for. The one thing that I have learnt, and is what I would teach, is that every subject you teach should have the capacity to change people's world view. So languages are a good one, for people to realise that things don't have to be called what they're called, to realise that your grammar is not unique: that's quite life- changing in a way, so that's a useful one. Maths is something that I really enjoyed doing, because it forces you to think carefully. If you read the newspapers and you think - you read the statistics, and people don't know what the hell they're doing with them. To be able to think logically is incredibly important and can change the way you view things. History, again, changes the way you view things. Geography can do that to some extent. In terms of science training, I think it's weird to think about - we are breeding a load of super-users, people have phones, I mean, my industry is built on video gaming, and I sometimes ask myself the question, 'Should I be doing my job? My industry exists on people wasting their lives playing video games.' And then most phone usage is spent playing Angry Birds, much more, I hate to think what percentage of time is spent. But I think we're developing a a lot of super-users of computers, as more people use them, does that encourage people to want to understand? Are people naturally more logical than they used to be? I don't know. It's quite interesting, if you think about all the bits and pieces. You've got an increasing number of devices and gadgets. There's questions of security, data transfer, people pondering questions like, 'I downloaded this song from iTunes. Can I pass it on to you?' There are legal ramifications, technological problems. Will people know about compression algorithms, will they care, if it's not really from a user perspective? But to appreciate those problems, and if I go into a school and I pitch what I do, I'll obviously be using iPhones as a starting point. But would I encourage...? Yes, obviously you need a healthy dose of science - teaching - that's another thing: how are they ever going to teach application design or something, if you want kids to be building apps for phones and iPads and that kind of junk - I don't know. Teaching technology. [2.00.] Yes, let's pretend it's 50-50. You need two sides. What you inherently - actually, here's a good question:

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based on what I think society suffers from, what do people lack more of: an artistic bent or a scientific bent? Let's go for the scientific bent. People lack - well, the thing is, it's scientific also in the sense of people's inherent prejudice, lack of objectivity. That includes historic objectivity. Logical reasoning is for everybody. Is science teaching important? You need all of it. I know the

worst taught subjects are languages. There's lots of science teachers without science qualifications: that's quite scary, and people do it really badly. And if you want a knowledge economy, if you really want that, then yes, you would force more people to do science because there's cash in it. You can physically make stuff. So if you want that, then yes, you would have to force more science on them.

SH: Ok. Hypothetically, if we have more young people interested in STEM subjects, taking them up at GCSE and A-Level, undergraduate level, then there will be many more for whom the STEM PhD becomes a feasible option. Do you think we should be looking to expand the STEM PhD population?

Will: I heard a lovely story about this. There's a very good book by a moral philosopher, called Justice, and it describes a cheerleader who's in a wheelchair, and the head cheerleader, her father wasn't very happy, because he believed that her presence degraded his daughter's performance. So I know PhD students who in this drive to get more people doing PhDs, feel disgruntled by the fact that the word PhD means less. Which I don't really put much stock by. It's amazing to think if somebody has a qualification - you can have the same qualification as somebody else, but you can completely different, so that's my understanding. My last job was in the finance sector. In the finance sector, most people are ludicrously underemployed, and there were lots of people in there doing pointless technical-type jobs, who should be doing PhD-level research, were very equipped to do so. They would all be more productive, and if they want to build companies, they should so. So I would say you need to morph current PhD populus, and I think if you really want a knowledge economy you would have to grow it. You would have to force to be more involved in it, and you would have to invest in it heavily. You'd have to change the grant system. I mean, you'd have to remove publications as being the main goal. It's really amusing to watch what has been built up. You know, what do people actually care about, and the consequences? And publications, they aren't important, in my opinion.

SH: And what about the person? Are there any characteristics that you think are important - in addition to the prerequisite academic qualifications - for undertaking the STEM PhD?

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Will: [5.00] Certainly if you want to flourish in the current environment, you ought or obviously you have to be extremely self-sufficient. I really need to think about what I would I would say - I used to think PhD students were incredibly clever, and you would have to be an amazing person to

head into a PhD. I've since been shown otherwise. Because it's a long slog, then, yes, you need to be self-sufficient, dedicated; in my personal opinion, you should be finding a home for your work throughout the PhD, and that's not in publications. There is some marketing involved. A lot of the papers I write are involved in - you have to be very good at pitching why this solution is better or worse than others. There aren't enough presentations. In March I presented to five different groups. So there's an academic group; I pitched to industry users, my management, A-level students, degree-level students: I pitched to all those people, and I think you should get PhD students do to that more, more of that, and to explain their research to more different people. In terms of marketing, I think they should. I think you have to love your subject; otherwise you won't survive.

SH: Ok. So my closing question is, if we think back to the concept of the 'knowledge economy', is it in any way an inspiring or motivating idea for you?

Will: I've never spoken to a PhD student about the knowledge economy. I have never heard an academic or a PhD student express the wish to productise their work. The phrase you might here is, 'Well, I could do that.' I don't think there is - I think good people will use it for its benefits, but it's just a nice phrase that you can lump any old junk under. So it's a good bit of marketing. It's a nice phrase. You can make some tiny initiatives around it. I don't notice any real progress. I'd be very interested to know of any forces at work on my supervisor to be able to demonstrate their adherence and trust in a knowledge economy vision. I don't know if that exists. And if they want to change how people do things - it doesn't look like they are. At the moment, as I've mentioned before, if you pull the funding, you will ask smaller questions that you can publish, you are less likely to be innovative, and you are less likely to contribute to the economy. Complete no brainer. If, however, you then want to say, 'Right, okay, we'll give you less money and we'll then start dealing with industry,' well, from what I've seen personally, it's my company that's been doing the chasing. We've been doing all the hard work, so the university doesn't particularly seem to want to get involved, which is quite strange. Oh well.

SH: That's all my questions; thank you very much for your time.