The Value of PhDs: the Impact of Doctoral Education in Research Intensive Employers

Final Report

Engineering & Physical Sciences Research Council (EPSRC)
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Executive Summary

DTZ was commissioned by the Engineering & Physical Sciences Research Council (EPSRC) to determine the broader value of the investment made by the EPSRC and others in doctoral programmes in the UK, particularly in non-academic organisations, in order to understand better the economic and social impacts that doctorate holders have.

This Executive Summary focuses on our key findings on impact, the main objective of the research.

- The majority of employers in research intensive organisations actively target doctorate holders as part of their recruitment process in their organisation. Doctorate holders are recruited by organisations because of the skills that they bring. This raises the capability of the organisations.

- **Direct impacts** are the most highly valued by the organisations. The main direct impacts sought are technical expertise (83% of survey respondents ranked this as ‘high’), innovative/creative thinking (75%), and problem solving and trouble shooting (68%).

- However, achieving indirect impacts is also seen as very important. The main **indirect impacts** sought are improving team working, networking and absorptive capacity (the ability to learn from technological advances). The increasing importance of collaborative working practices to the R&D industry is likely to increase the significance of such indirect impacts.

- These impacts flow through to hard commercial benefits. Around three-quarters of respondents to our survey rated doctorate holders’ contribution to the commercial performance of their organisation be either ‘high’ or ‘medium’; and 83% of respondents believed that doctorate holders had improved their position against competitors.

- It therefore seems clear that doctorate holders play a pivotal role in the delivery of commercial impact through their R&D contribution and fostering absorptive capacity in organisations. Their contribution helps to improve corporate performance through increasing turnover, productivity and profitability and decreasing costs.

- It is the generic research **competencies** of doctorate holders that are rated most highly by research intensive employers. Four key research skills are rated as ‘very important’: problem solving skills (by 75% of our survey); research skills/methodologies (63%); communication (59%); and data analysis abilities (56%).
• Doctorate holders are also recruited to raise R&D capacity in organisations through their recruitment, training and development of staff. They have the potential to become future leaders in organisations: in around half of our sample, those with doctorates are anticipated to be able to reach middle management within 2-4 years and senior management within 5-10 years. However, it is clear that the research skills of doctorate holders are valued more highly by companies than their broader based management and leadership abilities.

• Nearly all employers in our survey agreed that doctorate holders have the same or faster adaption times to their new roles on starting employment, in comparison with other graduate groups. This is also supported by findings from previous literature. The fostering of better links between academia and industry is improving the ability of doctorate holders to move from one area to the other.

• The strongest external impacts were: standards and good practice (73% of the survey rated this impact as ‘high’ or ‘medium’); environmental (61%); policy and regulatory (59%); and health and quality of life (51%). These impacts help to provide new knowledge and improved ways of working, which can be used by companies in the same sector; and new or enhanced products or processes, which enable successful developments in other business areas. Such impacts help to improve the wider economy and society.

• Chemicals and life sciences was the sector where doctoral impact was perceived to be highest. This is to be expected given that R&D is the essence of this sector, demonstrated by its share of total UK R&D expenditure.

• The level of doctorate holders’ impacts develops very strongly during their first two years with the organisation.

The figure below demonstrates, from an actual organisation, the types of impacts that are sought from doctorate holders and how these impacts are generated. This is developed further in our final conclusions section.
Example of Impact Transmission Mechanism – the UK Automotive Sector

Internal Impact of PhDs

Research & Advanced Engineering Centre
- Innovation leadership
- Capacity building
- Absorptive Capacity
200 staff (incl. 30 PhDs)

Product Development
- Receiving the innovations and applying to automotive manufacturing process
- Supply chain linkages
4,000 staff (incl. 40 – 50 PhDs)

Manufacturing & Distribution
- Assembly line production
- Distribution/sales function

External Impact of PhDs

Academic Linkages
- Research know-how
- PhD sponsorship/CASE studentships
- Recruitment

Supply Chain
- Collaborative research with suppliers
- Capacity building of suppliers
- Sustainability and performance of UK supplier base

Other Stakeholders
- Government – policy, etc.
- Research Councils – focus & funding
- Industry – SMMT, etc

Commercial Impact
- Turnover and profit
- Sustainability – long term customers
- Organisational reputation & image

Customers

Wider Impacts
- Health – passenger and pedestrian safety
- Environment – CO₂ emissions, transport efficiencies, etc.
1. Introduction

1.1 Study objectives

DTZ was commissioned by the Engineering & Physical Sciences Research Council (EPSRC) to undertake a study to measure the impact of doctorate holders on research intensive employers. Doctorates, in this context, refer to both PhDs and EngDs. The work was delivered over the period January 2010 to May 2011.

The purpose of the study was to help the EPSRC to better understand and articulate the benefits resulting from its investment in doctoral training in order to enable it to justify its spend on science and engineering and to inform where best value is being achieved, as well as assessing the wider benefits to the economy and society.

The study has addressed the following questions.

- What do employers gain from doctorate holders and how does this differ from the value gained from holders of other qualifications?
- In what ways do doctorate holders contribute to the competitiveness of the employer, both directly (e.g. through contribution to innovation via knowledge transfer, impact on absorptive capacity) and indirectly (e.g. through their influence on others around them)?

Overall, the EPSRC requires:

Quantitative and qualitative information on the economic impact of Research Councils’ investments in doctoral research training; this should consider the development of human capital, business and commercial impact, policy impact and more general impacts of quality of life factors.

1.2 Study context

Evidence has demonstrated a clear link between academic qualifications at the graduate level and positive labour market outcomes\(^1\), but there is less evidence on the types of impacts achieved by increasing levels of higher educational achievements at the postgraduate level.

This has become an important area of discussion as the number of UK students attaining qualifications at a Higher Education level has increased by 31% between 1996/97 and 2007/08\(^2\). In addition, the number of students obtaining doctorate level qualifications has also increased by 63% over the same time period\(^3\). Given the increase in students obtaining higher educational qualifications and doctorates, it is important to understand what these students go on to do, and what impact their qualifications have.

Research Councils in the UK (RCUK) are the public funding bodies for the research and science sectors. Each Research Council funds research and training activities in a different area of research. In total, the RCUK supports approximately 19,000 doctorate students at any one time, representing £300 million in public investment per annum.

This is a significant investment and, as pressure for resources tightens, it is important that the RCUK is able to justify spend by understanding, as fully as possible, the impact and value of the doctoral scholarships that they fund. Fundamental to this, is developing an understanding of what doctoral students go on to do in the labour market and by what routes.

There already exists a body of literature relating to doctoral students and their destinations\(^4\), what they earn and what professions they go into. However, there is a dearth of information, and a subsequent lack of understanding, relating to the wider social and economic impact of doctorates. It is therefore important that this study not only identifies the type of activities that EPSRC sector students undertake and where they go, but also assesses the value of those activities. Indeed, there is a significant lack of information about the views of employers on doctorates, the value employers attach to doctorates, and the roles doctoral graduates play in their employing organisations. Such information is vital to gain a fuller and more accurate picture of the impact of doctorates in the UK economy and society.

The objective of this study is therefore to provide a fuller understanding of the value of doctoral graduates and the contribution they make in organisational, economic, environmental, societal and policy terms.

### 1.3 Impact assessment framework

DTZ began the study by producing an *Impact Assessment Framework* for assessing the contribution of doctoral training using a logic model approach. Figure 1.1 details the four main stages in the framework:

- Firstly, what is the **investment** in the Research Councils’ doctoral programme (these are the ‘inputs’ into the impact model)?
- Secondly, how have these skills and experience **been applied** outside academia?
- Thirdly, how does the **transmission mechanism** operate, through which this knowledge and experience confers impact on the economy, the environment and society?
- Lastly, what is the **nature and scale of the impacts** generated?

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\(^2\) HESA data
[http://www.hesa.ac.uk/index.php?option=com_datatables&Itemid=121&task=show_category&catdex=3](http://www.hesa.ac.uk/index.php?option=com_datatables&Itemid=121&task=show_category&catdex=3)

\(^3\) HESA data, based on full and part time students,
[http://www.hesa.ac.uk/index.php?option=com_datatables&Itemid=121&task=show_category&catdex=3](http://www.hesa.ac.uk/index.php?option=com_datatables&Itemid=121&task=show_category&catdex=3)

\(^4\) Much of this relates to first destinations. There is less information of subsequent steps with the exception of a number of niche studies.
Figure 1.1 Impact framework for doctorates: A Logic Model

**Investment ("Inputs")**

- Funding
  - UK Research Councils
  - Employers
  - PhD Students
  - Other
  - 19,000 doctoral students at any one time

**Skills**
- Specialist knowledge
- Professional/management
- Entrepreneurial skills

**Development of Human Capital**

**Application ("Activities")**

- Sectors
  - Private Sector
  - Public Sector
  - Third Sector
  - (Academic n/a)

- RoI Profile
  - Job Type
  - Job "Strat"
  - Job "Reach"

- Organisational Context
  - Team Working
  - Knowledge Exchange
  - Learning Culture

**Classification System for Impact Assessment (Illustrative)**

**Economic**
- Production Management
- Research, Design & Development, etc.

**Environmental**
- CO2 Emissions Reduced
- Environmental Procedures/Policy

**Social**
- Health Benefits
- Employee Satisfaction
- Staff Retention/Development

**Direct (Absorptive Capacity)**
- Supply Chain Development
- Research Partners
- Customer Impacts

**Indirect (Spillovers)**
- Impacts on Suppliers, Customers & Partners

**The Nature & Scale of Impact**

**Economic Impact**
- New Firm Formation (spin-offs)
- Turnover
- Productivity/GVA
- Cluster Impact

**Environmental Impact**
- New Technologies (e.g. Renewables)
- Carbon Reduction Measures
- Sustainable Communities

**Social Impact**
- Alleviation of Deprivation/Poverty
- Improved Health
- Reduced Crime

Source: DTZ
This study attempts to build on the evidence base around the four core blocks of 'Investment', 'Application', 'Transmission Mechanism' and 'Benefits' to provide, for the first time, a real insight into the nature, range and scale of impacts generated by doctoral graduates.

1.4 Study method

The methodology needed to be flexible so that it could be adapted as the study progressed. The study was therefore undertaken using a two phase approach. The first phase involved mapping out the available evidence, particularly from previous literature and secondary sources. It attempted to identify ‘routes to market’ for those doctoral graduates entering non-academic employment. It also involved a pilot survey of 19 employers, after consultations with relevant stakeholders, on how impact is being generated by these graduates and on good practice. This was supplemented by 15 interviews with ‘umbrella organisations’ and representative bodies from industry and the professions.

This evidence base informed the second phase of the study, which involved a wider survey of 86 research-intensive employers to identify, more broadly, the impact of doctoral graduates across a range of employers/sectors. This quantitative telephone and web-based survey was delivered by Swift Research and the findings analysed by DTZ. These survey results were supplemented by qualitative data generated through 20 in-depth telephone interviews conducted by DTZ.

In summary:

- Phase 1 – focused on the understanding of impact and the ‘transmission mechanisms’; what types of impact and where they occur.

- Phase 2 – provided an overall assessment of impact on organisations, employees, the PhD graduates themselves and wider societal impacts, with a targeted approach based on the knowledge and lessons gained in Phase 1.

This phased approach allowed our understanding of impacts to evolve as the study progressed, and enabled us to identify the areas in which the study needed to be directed. Given that this is a new area of research, this approach was deemed appropriate as it allowed for feedback and dynamic learning during the course of the study.

Figures 1.2 and 1.3 illustrate the main stages in Phases 1 and 2 of the study respectively.
A Workshop to discuss the emerging results from Phase 1 and the implications for Phase 2 was held at the offices of the Department of Business, Innovation & Skills (BIS) on 30th March 2010. This involved DTZ and representatives from the Research Councils and other stakeholders. These are detailed in Appendix B.
Survey of Organisations — the focus of this research study was to be on those entering non-academic employment, therefore we proposed a survey of organisations across the UK to identify those that target doctoral graduates as well assessing the impact that these graduates are having on their organisations. This was on the basis that it is only those sectors/organisations that actively recruit doctorate holders or where doctorate holders could make a contribution that will be relevant to this part of the research. This was informed by the outcomes from Phase 1 of the research.

The questionnaire for the survey was designed by DTZ in conjunction with the project Steering Group and Swift Research Ltd: see Appendix F. Swift Research was responsible for the conduct of the survey and DTZ for the analysis of it.

The questionnaire included around 40 questions, mostly to capture quantitative data but also included a number of open-ended questions. It involved a mixture of a web based survey and a telephone survey to maximise flexibility in organisations responding. The survey took around 15 minutes to complete. Other methods were considered, for example, a postal survey and face-to-face interviews. However, postal surveys normally have a very low response rate and face-to-face interviews are very expensive to operate. We believed that a well structured telephone/web based survey was capable of eliciting the information we required in the most cost-effective fashion. DTZ’s follow-up through 20 in-depth telephone interviews also allowed us to probe and clarify particularly interesting responses from the survey.
The focus was on research intensive and innovative companies, of a variety of sizes, in four key sectors, which our work in Phase 1 demonstrated are research/innovation intensive industries that recruit engineering and physical science doctorates in sizeable numbers.

- Aerospace & Defence
- Chemistry & Life Sciences (including Pharmaceuticals)
- Electronics, IT & Communications
- Automotive.

EPSRC developed the contacts database and generated 256 contacts for us to use. This included multiple contacts in a number of organisations, particularly the larger ones. The rationale for this was that those representing different parts or functions of larger organisations may have different insights and views on doctoral graduates. This was subsequently demonstrated by a number of the responses.

We targeted a 50% response rate, which was achieved. Of the 126 responses received, it was clear that a number of responses were ‘duplicates’, as a result of different contacts responding in a similar way on behalf of their units within an organisation. Such responses were pooled into a single response. This left a database with 113 responses representing 86 different organisations.

Depth Interviews – we used the evidence from Phase 1 of the research and the survey findings to identify organisations and sectors of interest in which doctorate students/graduates are making significant impacts, or whose responses warranted further attention. Fifteen such organisations were then interviewed, with more focused probing and clarifying of responses to generate rich qualitative impact information which helped ‘tell the story’ of individual organisations and their sectors within which they operate. We were able to use this information to help describe the nature, process and scale of impact generated. This analysis was informed by all of the previous research undertaken in the study.

In addition, we also interviewed five other organisations drawn from other sectors which were perceived to be less research intensive, but which were also of interest to the client:

- Financial Services
- Creative Industries
- Energy.

Much of the detail in this report is drawn from these depth interviews, but we agreed with respondents that they would not be identified in reporting, therefore we have anonymised all examples provided.

1.5 Report structure

This Final Report presents our analysis and findings in an integrated fashion, drawing upon the research work from both Phases 1 and 2. The Report is structured as follows:

- **Section 2 – Impact of Doctoral Training** – this section focuses on the qualitative and quantitative analysis of impact generated from both the literature review and the surveys of employers and umbrella organisations.
• **Section 3 – Literature Review** – this presents our analysis of secondary data generated from an extensive review of key literature and data sources on the value and impact of doctorates. This was undertaken by DTZ in conjunction with Dr Arwen Raddon, our expert adviser.

• **Section 4 – Doctoral ‘Lifecycle’** – this presents an employer perspective on the recruitment, competencies, training and progression of doctorates. This helps to explain the ‘inputs’, ‘activities’ and ‘process’ in our analytical framework in Figure 1.1. This information provides the foundation for the impact assessment described in Section 2.

• **Section 5 – Summary & Conclusions** – the final section draws together the key findings from the research and draws out conclusions where appropriate. It also gives examples of how the impact ‘transmission mechanism’ works in practice.

Due to the volume of findings and the level of detail presented, a key findings summary is provided at the front of each of the main result sections (Sections 2 – 4).

**Acknowledgements**

DTZ would like to acknowledge the support of the Steering Group for this study, led by Dr. Sue Smart of EPSRC. In particular, the work of Dr. Rebecca Stelianos in drawing together the company database for the telephone and web-based survey was much appreciated.

We would also like to thank the wide range of companies and umbrella organisations whose representatives participated in the consultation process and gave their objective and independent views on the contribution of doctorate qualified staff.

Finally, we benefited from the constructive inputs from those attending the one day conference hosted by the Department for Business Information and Skills in March 2010.

A full list of consultees is presented in Appendix B.
2. **Impact of Doctoral Education**

<table>
<thead>
<tr>
<th>Key findings</th>
</tr>
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<tbody>
<tr>
<td><strong>Economic Context</strong> – the private sector invested £133 billion in innovation in the UK in 2007, representing c. 14% of private sector GVA. This is estimated to be accountable for two-thirds of the UK’s private sector labour productivity growth (2000-07), increasing productivity by an average of 1.8 percentage points per annum.</td>
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<tr>
<td><strong>Impact</strong> – the contribution of doctorate holders is assessed to be extremely positive across all of the parameters examined:</td>
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<tr>
<td>- <em>Organisational impact</em> – the direct and indirect impacts they generate have been rated very highly:</td>
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<tr>
<td>- <em>Commercial impact</em> – 74% of respondents rated doctorate holder contribution to the commercial performance of their organisation be either ‘high’ or ‘medium’; and 83% of respondents believed that doctorate holders had improved their position against competitors.</td>
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<td>- <em>External impacts</em> – the strongest contributions rated as ‘high’ and ‘medium’ impact were:</td>
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<td><strong>Conclusion on Impact</strong> – these very strong findings are of fundamental importance to the conclusions of this research study:</td>
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<td>- Firstly, that doctorate holders play a pivotal role in the delivery of commercial impact through their research and development contribution, fostering absorptive capacity, external communication, etc.;</td>
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<tr>
<td>- Secondly, that their contribution flows through to hard commercial benefits in terms of improved corporate performance – increased turnover, improved productivity, reduced costs and improved profitability; and</td>
</tr>
<tr>
<td>- Thirdly, that their impact confers important external benefits to the government, suppliers, customers and academia. This delivers a wider range of impacts in areas such as policy and regulation, the environment, health and wider societal benefits.</td>
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</table>

Finally, this doctoral contribution supports the most important high technology and innovative sectors in the UK economy, sectors which are of fundamental importance for the future of our economy.
2.1 Introduction

This section presents DTZ's analysis and conclusions on the impact of doctoral education. This represents the fundamental output of the study as it breaks new ground in improving our understanding of the importance of, and contribution derived from, doctoral education. For this reason it was agreed with the Steering Group that it should be presented at the start of the report. The reader should therefore be aware that a lot of the supporting evidence relevant to the contribution of doctoral education is presented in the succeeding sections 3 and 4 and the Appendices. Section 2 is structured under the following sub-headings:

- UK economic context for impact assessment
- Impact on organisational performance (excluding direct commercial benefit)
- Impact on the commercial performance of employers
- Wider external impacts resulting from doctoral education.

The impact assessment has been based upon the following research elements:

- Phase 1 literature review (see Section 3 of the report)
- Phase 1 telephone survey of employers (19) and sector umbrella organisations (15) conducted by DTZ – the topic guide for the consultations is presented in Appendix C; and the qualitative findings are presented in Appendices D and E
- Phase 2 telephone and web-based survey of research-intensive employers (113 responses in 86 organisations) conducted by Swift Research – the questionnaire is presented in Appendix F and the tabulated results in Appendix G
- Phase 2 follow-up depth interviews with 20 employers conducted by DTZ.

A more detailed description of the employer survey methodology and sample frame is presented in Section 4 ‘Respondent Profile’ and is not repeated here.

2.2 UK Economic Context for Impact Assessment

Prior to analysing the impact data and research findings it is appropriate to set the economic context within which this information sits.

2.2.1 Importance of R&D Expenditure

Innovation – Based upon the wider definition of ‘innovation’, the private sector invested £133 billion in innovation in the UK in 2007, about 14% of private sector GVA, which is estimated to be accountable for two-thirds of the UK’s private sector labour productivity growth (2000-07), increasing productivity by an average of 1.8 percentage points per annum\(^5\).

Research & Development – Given the focus of the Phase 2 survey on research-intensive employers, it is important to understand the nature, scale and contribution of the UK’s private sector research and development activity:

- Total ‘Business Enterprise Research & Development (BERD) expenditure in the UK in 2009 was £15.6 billion, a 2.5% fall on 2008.

\(^5\) NESTA, *op cit.*
- This represents 1.1% of UK GDP\(^6\).
- Total R&D (including government) is estimated at 1.6% of UK GDP.
- R&D investment is also estimated to be 1.5% of UK market sector GVA\(^7\).

Clearly, R&D activity in its own right is an important element of the UK economy, accounting for over 1% of GDP and nearly £16 billion of expenditure. Furthermore, around 151,000 FTEs are employed on R&D in UK businesses (2009):

- 85,000 of these are scientists and engineers
- 40,000 are technicians, laboratory assistants and draughtsmen; and
- 27,000 are administrative, clerical, industrial and other staff\(^8\).

This R&D occupational structure is characterised by a disproportionately high share of professional level staff (56%) compared to other sectors and activities in the economy.

**Employment** - As will be further outlined in Section 3, around one-quarter of engineering and physical science PhDs enter manufacturing industry (particularly chemical and pharmaceutical industries) and around one-fifth enter business, finance & IT.

In summary, these are extremely strong statistics which demonstrate the importance of R&D and innovation as the key drivers of the UK economy, especially in high technology and manufacturing sectors – see below.

The focus of this research study is therefore to identify and assess the contribution and impact which doctoral education plays in supporting UK R&D/innovation.

### 2.2.2 Contribution of Innovation Intensive Sectors

Based on the lessons learned from Phase 1, following discussions with the client Steering Group, a conscious decision was taken to focus the Phase 2 survey on research-intensive employers. The majority of the survey sample was drawn from four key hi-tech sectors:

- Chemicals and life sciences (including pharmaceuticals)
- Automotive industry and engine manufacture
- Electronics, IT and communications
- Aerospace and defence.

ONS statistics\(^9\) suggests that these are the key R&D sectors in the UK economy. Pharmaceuticals alone represents 28% of total R&D expenditure, followed by aerospace (9.4%), computer and related activities (9.3%), motor vehicles and parts (7.3%) and telecommunications (7.0%).

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\(^6\) ONS, *UK Business Enterprise Research and Development 2009. Statistical Bulletin*

\(^7\) NESTA, *The Innovation Index – measuring the UK’s investment in innovation and its effects* November 2009.

\(^8\) ONS, *op cit.*

\(^9\) ONS, *op cit.*
We estimated the contribution of research intensive sectors to the overall economy by using Annual Business Inquiry (ABI) data for 2008 from the ONS to calculate their contribution to GVA at basic prices. Manufacturing industry makes up around 10% of total UK GVA. Some of the key sectors relevant to this study are detailed in Table 2.1 below. Again, this demonstrates the importance to the UK economy of supporting these key growth sectors through world class R&D and innovation.

<table>
<thead>
<tr>
<th>Industry</th>
<th>Approximate GVA at basic prices (£ million)</th>
<th>% of total GVA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manufacture of chemicals &amp; chemical products</td>
<td>10,645</td>
<td>0.6%</td>
</tr>
<tr>
<td>Manufacture of basic pharmaceutical products &amp; preparations</td>
<td>8,643</td>
<td>0.5%</td>
</tr>
<tr>
<td>Engineering &amp; related consultancy</td>
<td>20,774</td>
<td>1.1%</td>
</tr>
<tr>
<td>Manufacture of electronics &amp; electrical equipment</td>
<td>12,703</td>
<td>0.7%</td>
</tr>
<tr>
<td>IT(^{10})</td>
<td>44,317</td>
<td>2.4%</td>
</tr>
</tbody>
</table>

Source: DTZ analysis of ONS data

2.3 Organisational Impact of Doctorate Holders

2.3.1 Impact Evidence from Employer Survey

The contribution of doctorate holders in improving the capabilities of their organisation has been rated very highly by those consulted. Impact can be classified into two categories, with a marked variation in respondents’ perceptions on the level of impact: see Figure 2.1.

- **Direct impact** due to the skills of the individual (assessed as ‘high’):
  - Technical expertise 83%
  - Innovative /creative thinking 75%
  - Problem solving and trouble-shooting capabilities 68%.

- **Indirect impact** attributable to doctorate holders’ communication, team working and networking competencies (assessed as ‘high’):
  - Absorptive capacity of organisation 57%
  - Access to knowledge networks outside company 46%
  - Flows of knowledge within the company 43%
  - Promotion of learning culture 42%
  - Skills and productivity of other employees 21%.

\(^{10}\) Defined as computer programming, consultancy and related services, and information service activities
Not surprisingly, direct impact is rated as having a higher impact that indirect impact. As explained in Section 4, the competencies of doctorate holders valued most highly by research-intensive employers relate to their ‘generic research’ skills, which are critical for the effective execution of a research function: problem solving, research skills/ methodologies, communication and data analysis abilities. It is therefore very reassuring to see that employers credit the ‘direct impact’ of their doctorate holders to this same generic research skills set.

However, the indirect impact findings are also very strong and they relate to the contribution of doctorate holders in improving the absorptive capacity of their organisations for which they work. This is attributable to their communication, team working and networking internally and externally with academic and industrial partners.

Figure 2.1 – Impact of Doctorate Holders on Organisational Capabilities (Q.13)

For both direct and indirect impacts, the findings in Figure 2.1 are extremely positive because, if both ‘high’ and ‘medium’ impact responses are added together, direct impact is 98% – 100% and indirect impact lies in the range 72% - 95%.
The sector which has the highest impact rating is chemicals and life sciences: see Table 2.2. For most of the impact categories, a higher percentage of respondents in this sector rate doctoral impact to be ‘high’. The only exception is ‘access to knowledge networks outside the company’, where the automotive sector is significantly higher, with 80% of respondents in their sector rating the impact of doctorate holders to be ‘high’ as opposed to 51% in chemicals and life sciences. Intuitively, this is what one would expect given the nature of chemicals and life sciences sector:

- Research is the very essence of these organisations, more so than the other sectors that have been sampled. As shown in Section 2, pharmaceuticals R&D expenditure alone is 28% of total UK R&D expenditure. This is further evidenced in the survey by the percentage of employers which rate R&D for new product and process development in their organisation to be ‘essential’ – see Table 4.4 in Section 4:
  - Chemicals and life sciences – 90%
  - Automotive – 80%
  - Electronics, IT and communications – 69%
  - Aerospace and defence – 65%

- Unlike the other sectors, the manufacturing element for pharmaceutical and life sciences is quite different and less of a focus for the sector. However, in the automotive, aerospace and IT sectors, lean manufacturing and efficiency is a major issue. Hence, it is understandable that doctorate holders engaged in research in these sectors will have less of an organisational impact compared to the chemicals /life sciences sector.

<table>
<thead>
<tr>
<th>Sector</th>
<th>Creative thinking</th>
<th>Problem solving</th>
<th>Knowledge flows</th>
<th>Learning culture</th>
<th>Productivity of staff</th>
<th>Knowledge networks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemicals &amp; life sciences</td>
<td>88%</td>
<td>85%</td>
<td>59%</td>
<td>56%</td>
<td>34%</td>
<td>51%</td>
</tr>
<tr>
<td>(n=41)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Automotive</td>
<td>60%</td>
<td>47%</td>
<td>53%</td>
<td>47%</td>
<td>13%</td>
<td><strong>80%</strong></td>
</tr>
<tr>
<td>(n=15)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronics &amp; IT (n=16)</td>
<td>81%</td>
<td>63%</td>
<td>31%</td>
<td>25%</td>
<td>19%</td>
<td>25%</td>
</tr>
<tr>
<td>Aerospace &amp; defence (n=26)</td>
<td>65%</td>
<td>58%</td>
<td>27%</td>
<td>35%</td>
<td>12%</td>
<td>39%</td>
</tr>
</tbody>
</table>

Source: DTZ

Analysis of impact by size of company does not reveal any marked variations other than the interesting fact that small companies tend to rate doctoral impact as high, if not higher, for a number of the variables. This may correlate to the ease with which doctoral staff can exert influence in organisations employing less than 50 staff.
Examples of Organisational Impact

**Problem Solving**
“A good example of impact was in the predictive understanding of materials aging. PhD holders put this on a proper scientific basis with theoretical depth. As a result, the company could progress on this much more quickly. It also has ‘mission benefits’ e.g. for the company’s relationship with [main contractor].”

**University Collaboration**
“A key skill of our doctorate holders is their ability to network knowledge, skills, tools and techniques from the university sector in the UK. Examples include:
- University A – research project on understanding drug polymer interactions
- University B – EngD programme with their Chemical Engineering Department – this has proved very fruitful for the recruitment of staff
- University C – through staff contacts, we have been able to network through to [another university] to secure access to key research tools and techniques
- University D – the colloid formulation skills of their Chemical Engineering Department has helped build our understanding of other systems and low dosage performance in vivo”

**Technical Specialists**
“A number of our PhDs have been appointed as ‘Technical Specialists’, where their leading edge knowledge means that they provide a wider ambassadorial function on behalf of our company. They talk at conferences and become known in the industry for their specialism. This helps build our company’s reputation and image with our key stakeholders. They also build a portfolio of university based research for their area of the business:
- PhD – pedestrian safety specialist
- PhD – active safety specialist
- PhD – hybrid car specialist
- PhD – low carbon technology specialist.”

“PhDs have impacts because of their attention to detail and their expertise in test techniques to ensure accuracy. The techniques, methods and processes that they develop can also have wider impacts across the company in informing other types of research and innovation.”

**Collaboration & Networking**
“One such case – a decade or so ago, a post-doctorate came to us and had a vision for increasing substantially our involvement in certain European programmes by working in a network of people that he had begun to establish around the world. He did this successfully and he increased our business activity in this area. It was driven by one guy, his vision and his contacts outside of this organisation.”
2.3.2 Impact Evidence from Literature Review

**Absorptive Capacity** – in Figure 2.1, the ‘high’ impact rating of doctorate holders’ contribution to the improvement of the absorptive capacity in 57% of employers surveyed is a very strong finding. Absorptive capacity is the fundamental building block for effective knowledge exchange between centres of research excellence and the corporate sector. The fact that doctorate holders are centre stage in facilitating this process is evidence of their pivotal role in the impact ‘transmission mechanism’.

This finding is supported by the work of the CIHE\(^\text{11}\) in their investigation of the factors that impact on absorptive capacity: see Figure 2.2. Their work has positioned PhDs, CASE studentships and EngD programmes as being correlated to ‘high absorptive’ capacity employers and to research outputs related to R&D development at the more groundbreaking end of the research spectrum. Our research findings therefore build on their case study evidence by identifying a causal relationship, whereby doctorate holders actually improve the absorptive capacity of their employers.

**Figure 2.2 – Factors impacting on absorptive capacity**

<table>
<thead>
<tr>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project Modality</strong></td>
<td></td>
</tr>
<tr>
<td>Innovation Vouchers</td>
<td>Sponsored/Collaborative Research</td>
</tr>
<tr>
<td>KTPs</td>
<td>EngD / PhD / CASE</td>
</tr>
<tr>
<td></td>
<td>Tech Licensing</td>
</tr>
<tr>
<td><strong>Type of Outcome</strong></td>
<td></td>
</tr>
<tr>
<td>Problem Solving and Project Formulation</td>
<td>Research &amp; Technology Development</td>
</tr>
<tr>
<td>Capability Development</td>
<td>Strategic Shift</td>
</tr>
<tr>
<td>Process Change</td>
<td></td>
</tr>
</tbody>
</table>

Source: CIHE

\(^{11}\) Absorbing Research: the Role of University Research in Business and Market Innovation, CIHE, May 2010
Impact Evidence from the Literature Review

Doctorate holders stimulate the ‘absorptive capacity’ of a company, whereby they improve the ability of a firm to learn about other technology advances. The ability to adapt new technology and science often depends on internal capabilities, and scientifically and technologically qualified members of staff facilitate this process. They take a ‘gate-keeping’ role, monitoring and identifying external information, and making it applicable and available to the firm and its other employees. This has been labelled as “Two faces of R&D”, and it is recognised that, on occasion, the absorptive capacity can be as important as innovation itself.

Companies that employ PhD holders also benefit from ‘technology exchange’. This is closely linked to absorptive capacity but focuses on taking advantage of technology transfer and exchange in a collaborative fashion. This is also important during development and change, to know what is available externally to the firm, i.e. ‘knowledge of knowledge’, and to have access to it through networks. Globalisation of research also means that connections with international networks are increasingly important, as is the ‘translation’ of this knowledge to the company’s specific needs.\textsuperscript{12}

In summary, doctorate holders bring with them skills, working methods and networks that they can apply to the industrial environment. They have the ability to solve complex problems, conduct research and develop new ideas. Furthermore, they are seen as bringing rapid impact to their employing organisations, representing a good return on investment in staff recruitment and development.

2.4 Commercial Impact of Doctorate Holders

2.4.1 Impact Evidence from Employer Survey

The results confirmed that the enhanced organisational capabilities attributable to doctorate holders flow through to hard commercial impact: see Figure 2.3. Respondents assessed their impact very positively as follows:

- Improved commercial performance – 74% of respondents rated doctorate holder contribution to be either ‘high’ or ‘medium’; and

- Improved position relative to competitors – 83% of respondents rated doctorate holder contribution to be either ‘high’ or ‘medium’

\textsuperscript{12} The Role of PhDs in the Smart Economy, Forfas/Advisory Science Council, December 2009
These very strong findings are of fundamental importance to the conclusions of this research study:

- Firstly, that doctorate holders play a pivotal role in the delivery of commercial impact through their research and development contribution, fostering absorptive capacity, etc.; and
- Secondly, that their contribution flows through to hard commercial benefits in terms of improved corporate performance – increased turnover, improved productivity, reduced costs and improved profitability.

In analysing these results sectorally, again, it is the chemicals and life sciences sector that attributes a higher level of impact on average compared to the other sectors – see Table 2.3 and Figures 2.4 and 2.5. In aerospace and defence, there is still believed to be commercial impact from doctorate holders, but it tended to be ranked ‘medium’ rather than ‘high’.
Figure 2.4 – Commercial Impact of Doctorate Holders by Sector – Improved commercial performance (Q.14)

Source: DTZ

Figure 2.5 – Commercial Impact of Doctorate Holders by Sector – Improved Position Relative to Competitors (Q.14)

Source: DTZ
Examples of Commercial Impact

Exploiting Postdoc Know-how

“A PhD qualified individual with relevant industry experience was recruited by our team. The skills and know-how from his PhD were invaluable in that he could undertake software development and modelling of how structures deformed under load for products in the aerospace industry. This brought direct commercial benefits to our company:

- Through the provision of consultancy services and advice, which this modelling and analytical capability supported. It allowed us to deal with real problems in real time
- Through the sale of the model and its IP to third parties in the industry.”

Innovation

“There are numerous examples of major technological breakthroughs, where the teams have been led and supported by doctorate holders. This includes the following:

- Dual view screens
- Advanced active safety systems
- Advanced hybrid models in development.

This ensures that our vehicles are competitive in the market place in terms of new features and innovation and so are perceived as up-to-date and appealing to the customer. This translates into sales, income and profit.”

“The sharp edge in investment management is in the construction of innovative products and funds, the use of instruments and structured products; which are complex, dangerous not to control and more complex than your average equity and bond in behaviour. The ability of a business to work with, invest in, structure products around and operationally control the complex end is a key component of competitiveness. That tends to be very strongly populated by PhDs.”

Competitive Performance

“Our company’s market focus is on tackling very challenging disease areas. This requires a lot more skill to turn chemicals into market leading medicines in a reliable and systematic fashion. It is very difficult to delivery 21st century pharma solutions. ‘First mover advantage’ is also critical. A PhD led research project in the UK has led to the release of a product for the treatment of diabetes in the US market. It involved the fabrication and synthesis of a slow absorption and fast absorption products into one pill. This is the first product of its kind to hit the market and initial sales are exceeding expectations.”
2.4.2 Impact Evidence from Literature Review

As explained in Section 3, the body of literature relating to ‘hard’ commercial impact arising from doctoral education is very limited. However, we did identify a BERD study in Ireland which provides some supporting evidence of the contribution of doctoral qualified staff, although the direct causal effect is difficult to determine:\(^\text{13}\):

> Excerpt from Section 3 – Literature Review

The BERD survey in Ireland showed that R&D active firms who have PhD employees demonstrate 2.5 times greater patenting levels than those firms that do not employ PhD graduates. The firms also have greater collaboration with higher education. The BERD data shows that 29% of R&D active companies employ PhD graduates, but these firms account for 70% of the R&D expenditure in Ireland. While these are positive findings, it is not possible to determine whether the high levels of R&D expenditure is the reason why PhDs are recruited by these firms or whether it is employing PhD holders that is helping to generate the higher levels of R&D expenditure.

2.5 External Impacts of Doctorate Holders

Although not quite as high as their direct commercial impact, the survey respondents believe that doctorate holders generate a significant impact outside their immediate organisation:

- *New knowledge or improved ways of doing things* which are used by other companies in the same sector or area of business – 77% of respondents assessed the contribution of doctorate holders to be either ‘high’ or ‘medium’ level impact; and

- *New or enhanced products or processes* which enable successful developments in other business areas (e.g. in IT hardware/software) – 66% of respondents assessed the contribution of doctorate holders to be either ‘high’ or ‘medium’ level impact.

In terms of the nature of these external impacts, Figure 2.6 illustrates the major categories that were assessed. From the six impact categories, there is a two tier classification in impact between the ‘top four’ and the ‘bottom two’:

*Most important external impacts* (‘high’ and ‘medium’ impact):
- Standards and good practice – 73%
- Environmental – 61%
- Policy and regulatory – 59%
- Health and quality of life – 51%

*Less important external impacts* (‘high’ and ‘medium’ impact):
- Societal – 47%
- Cultural – 35%

\(^{13}\) *The Role of PhDs in the Smart Economy*, Forfas/Advisory Science Council, December 2009
It is interesting to see how the nature of the sector influences the strength of these wider external effects. For example, the automotive sector leads in the area of environmental contribution (40% of respondents rating impact as ‘high’), whereas chemicals/life sciences lead on health and quality of life (63% of respondents rating impact as ‘high’): see Table 2.4. Across the board, the chemicals/life sciences and automotive sectors are perceived to have the strongest external impacts.

### Table 2.4 – Wider External Impacts by Sector

<table>
<thead>
<tr>
<th>Sector</th>
<th>Policy/ regulatory</th>
<th>Standards</th>
<th>Environmental</th>
<th>Health</th>
<th>Societal</th>
<th>Cultural</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemicals/life sciences</td>
<td>34%</td>
<td>32%</td>
<td>22%</td>
<td>63%</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>(n=41)</td>
<td>(n=15)</td>
<td>(n=16)</td>
<td>(n=26)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Automotive</td>
<td>20%</td>
<td>33%</td>
<td>40%</td>
<td>7%</td>
<td>20%</td>
<td>7%</td>
</tr>
<tr>
<td>(n=15)</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electronics &amp; IT</td>
<td>13%</td>
<td>6%</td>
<td>6%</td>
<td>0%</td>
<td>6%</td>
<td>0%</td>
</tr>
<tr>
<td>(n=16)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aerospace &amp; defence</td>
<td>15%</td>
<td>15%</td>
<td>12%</td>
<td>4%</td>
<td>8%</td>
<td>4%</td>
</tr>
<tr>
<td>(n=26)</td>
<td></td>
<td></td>
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</tbody>
</table>

Source: DTZ
The depth interviews provided wide-ranging evidence to support these quantitative findings:

**Examples of External Impacts**

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Policy, Regulation &amp; Standards</strong></td>
<td>“A doctorate holder within the company sits on the European fuel regulatory body, representing the UK.”</td>
</tr>
<tr>
<td></td>
<td>“Our doctorate holders act as ambassadors for our business with the scientific, government and commercial communities. Examples include:</td>
</tr>
<tr>
<td></td>
<td>- <em>Regulation</em> - regulatory advice for medicines, where the opinion of our experts is called upon. This includes the European Medicines Agency (EMA), the Medicine and Healthcare Regulatory Agency (MHRA) and the Food and Drug Administration (FDA) in the US.</td>
</tr>
<tr>
<td></td>
<td>- <em>Policy</em> – serving on expert committees and advisory boards (government, NGOs and industry) as subject matter experts to help develop policy, guidelines and industry standards.”</td>
</tr>
<tr>
<td></td>
<td>“Our specialists also liaise with Government, the Research Councils and the Society of Motor Manufacturers and Traders (SMMT) on strategy, policy, industry standards, environmental and societal issues. For example:</td>
</tr>
<tr>
<td></td>
<td>- Process improvements, measurement standards and design standards</td>
</tr>
<tr>
<td></td>
<td>- Development of policy and best practice”</td>
</tr>
<tr>
<td></td>
<td>“Our company is represented on review panels with the Research Councils. This is seen as, ‘giving something back to the system’. It also improves the company’s visibility, provides good marketing and allows for networking opportunities. It also enables the company to help to set standards in the industry and influence policy.”</td>
</tr>
<tr>
<td><strong>Environmental Impact</strong></td>
<td>“Central to our research is the development of low carbon technologies to reduce the impact of our vehicles. We are also heavily involved in researching journey planning and multi-modal choice – where car transport fits most effectively with train/plane.”</td>
</tr>
<tr>
<td></td>
<td>“We are currently working with a university on the fuel economy of cars, alongside a major energy company. This work, led by PhD students, has produced a 1% fuel economy on a new diesel engine. This is very significant for our business as it helps us to maintain a competitive advantage as well as leading to wider environmental gains. It can also produce wider economic gains for the whole of the UK as our competiveness helps to protect British jobs.”</td>
</tr>
<tr>
<td></td>
<td>“An area where wider impacts are being made is ‘green chemistry’, with a focus on reducing waste, and therefore costs, through better use of scarce resources. This is achieved by considering the environmental impact of healthcare products and their design, delivery and manufacturing far more closely and actively pursuing waste reduction strategies. This is also transferable to other industries. There are a range of drivers behind this including government, customers and industry.”</td>
</tr>
</tbody>
</table>
Health & Quality of Life

“The rationale for our company is the development of new pharmaceutical products for the treatment of illnesses and to improve health, quality of life and length of life.”

“Those working in healthcare and developing medicines will obviously generate wide-ranging health impacts. If the industry is successful, society will gain major health benefits.”

“From the innovation led by doctorate holders, our company is heavily involved in supporting the government’s policy goals relating to the environment, health and safety. For example, we are concerned not just with the safety of vehicle drivers and passengers, but also pedestrians. We need to understand society and the individual and the changes in both. For example, we need to consider the blind person crossing the road who cannot see the car coming.”

“Our work does have much wider social impacts. It is trying to identify and develop new drugs to improve life expectancy and quality of life. There are also wider economic benefits, e.g. in helping people to recover and get back to work as well as boosting the overall drug industry and helping it to grow to meet societal needs.”

Wider Societal Impact

“A good example of wider impact is our company’s work with Norway on the verification of arms reduction. PhD scientists lead some of this work and produced an innovative and professional approach to solving this problem. It also helped to foster links and gain commitment from other governments to arms reduction.”

The survey findings demonstrate that the level of doctorate holders’ impact develops very strongly during their first two years with the organisation. The percentage of respondents who assessed their impact as being ‘high’ increased dramatically over this period:

- ‘High’ impact from the outset – 27%
- ‘High’ impact after initial training – 45%
- ‘High’ impact after a couple of years’ experience – 74%.
3. Literature review

Key findings

- Academia is the largest employment sector as a first destination for PhD graduates.
- The occupational ties appear to be strong, and scientific R&D and researchers represent the most common occupations for PhD graduates of physical sciences and engineering.
- The supply of physical sciences and engineering PhD graduates has been stable and some modest growth in postgraduates within these subjects has been seen in recent years.
- PhD holders appear to be recruited because they can drive higher levels of innovation, absorptive capacity, rapid return on investment, recruitment and training, and they have the potential to become future leaders in organisations.
- Chemistry and physics represent the most popular subjects for UK domiciled doctoral students.
- Manufacturing and business, finance & IT are the largest industry employment sectors for PhD graduates of physical sciences and mathematics.
- Possible wider impacts to the economy, the environment and society are more difficult to identify and quantify.

3.1 Introduction

An extensive review of key literature and data sources on the value and impact of PhDs was undertaken by the DTZ team and Dr. Arwen Raddon, our expert adviser. This review was to enable the study team to:

- provide an overview of the key issues identified in the literature;
- map out the career paths of PhD graduates, particularly in the science and engineering sectors; and
- identify gaps in the literature where further research is required. Where possible this was factored into our survey of employers in Phase 2.

The literature review has informed our understanding of the full range of activities that PhD students are involved in, the market for PhD students, and employers’ views and perceptions. Although significant gaps remain in the existing research and literature – for example on the uptake and impact of PhDs in a number of economic sectors – the available quantitative and qualitative impacts (for the individual, the employer and wider society) have been investigated.

DTZ Research assisted the study team in identifying literature and data sources, national and international, with potential relevance to the study. We subsequently reviewed over 100 individual articles/papers, but focused on 24 sources of literature that met some or all of the following criteria, which were agreed with the project Steering Group:

- It considers impact of PhD students (11 sources)
- It has a focus on employers/organisations (12 sources)
- It considers destination of PhD students (13 sources)
- It has a focus on physical sciences and engineering PhDs (4 sources).
Only 11 of these sources focused on impact, which highlights the paucity of existing literature on the subject and the requirement for further primary research. A full list of all the sources considered is attached in Appendix A.

The remainder of this section considers the following key issues from the review of the existing literature.

1. PhD graduates and their destination
   - Supply
   - Destinations
2. Employment
   - Employer demand
   - Skills for employment
   - Barriers to employment
3. Impact
   - Individual impact
   - Employer impact
   - Social impact

3.2 PhD graduates and their destinations

This sub section provides context on PhD graduates in the UK, including their numbers, subjects and destinations.

3.2.1 Stock

A paper by the DTI (2006) estimated that there are 178,000 doctorate holders in the UK with Science, Engineering & Technology (SET) skills. This is nearly 80% of all doctorate holders. The main subjects of these degree holders are:

- Physical sciences – 49,000
- Biological sciences – 46,000
- Medicine & dentistry – 22,000
- Medical-related subjects – 21,000
- Engineering – 18,000
- Maths/computer sciences – 15,000.

Just under half (48%) of SET doctorates are in SET occupations. 17% are in teaching and the remaining 35% are in non-SET occupations.¹⁴

3.2.2 Supply

Overall, the total number of final year PhD students at UK universities between 1999 and 2003 grew by 31%. A major part of this growth was the rise in part-time UK students (+72%) and overseas full-time researchers (+65%). In these years, the physical sciences’ PhDs accounted for 24% of UK-domiciled PhD graduates and engineering represented 9%.¹⁵

¹⁵ What Do PhDs Do?, UK GRAD Programme, Careers Research and Advisory Centre, 2004
The share of physical sciences and engineering PhD graduates was stable during the subsequent four-year period. Between 2003 and 2007, a total of 11,845 UK-domiciled students graduated with a PhD degree in these disciplines. These graduates represented 33% of the total UK-domiciled PhD graduates.\textsuperscript{16} The total stock of EPSRC funded studentships in April 2007 was 7,903.\textsuperscript{17}

In terms of research postgraduates, the number of physical sciences’ full time equivalent (FTE) students increased by 7% between 2002-03 and 2006-07 and engineering & technology FTEs increased by 8%.\textsuperscript{18} This growth represents fairly modest levels compared to other subject areas, where the average growth across all subjects was 11%.

The graph below shows the physical sciences and engineering discipline degrees by subject area. Chemistry (24%) and physics (13%) represent the most popular subjects, and most of the other subjects represent a share between 3%-7%.

\textbf{Figure 3.1 UK-domiciled doctoral graduate population by subject 2003-2007}

\[\text{Source: What do researchers do?}\]

\section*{3.2.3 Destinations}

The Roberts Review (2002) found that, based on the Labour Force Survey (LFS), for Science, Engineering and Technology (SET) postgraduates, those in engineering, physical science and mathematics are more likely to be economically active than those with postgraduate qualifications in biological, computer and social sciences.\textsuperscript{19} This means that a higher share of these postgraduates is either working or seeking employment.

\textsuperscript{16} \textit{What do researchers do?} Vitae, 2009
\textsuperscript{17} \textit{Doctoral Career Pathways, Skills and Training Options analysis for the collection of information about the early careers of UK Doctoral Graduates}, University of Warwick, 2008.
\textsuperscript{18} \textit{Postgraduate Education in the United Kingdom}, Higher Education Policy Institute and The British Library, January 2010.
\textsuperscript{19} \textit{SET for success: the supply of people with science, technology, engineering and mathematics skills}, The Report of the Sir Gareth Roberts Review, 2002 Para 1.19
Vitae, and its predecessor the UK GRAD Programme, provide employment destination analysis of UK-domiciled doctoral graduates by subject. In 2004, the UK GRAD Programme published results based on the first destination of awarded UK-domiciled doctorates from UK universities in 2003. Vitae (2009) builds on this initial report and provides an update of results as well as additional information. The 2009 results are based on first destination information from doctoral graduates between 2003 and 2007, thus providing a much larger sample.

The 2004 analysis of the first destination of PhD graduates found that the share of physical sciences and engineering graduates believed to be unemployed was 4.7%, representing a higher share than arts & humanities (4.5%), social sciences (2.1%) and biological & biomedical (2.0%).20 This rate has subsequently reduced, but across 2003-2007 graduates, physical sciences and engineering still represented the highest unemployment figure with 4.5%. In the latest survey of 2007 graduates, the rate had been reduced further to 3.9%, which, together with biological sciences, still represents the highest level of unemployment.

Figure 3.2 illustrates the findings of the Vitae 2009 analysis. The findings also show that graduates of physical sciences and engineering and biomedical sciences are more likely to be working or studying abroad, compared to other disciplines. This can be partly explained in that these skill areas, particularly engineering, are considered to be global professions with large worldwide employers seeking graduates and there is a highly competitive international market in these areas.

Figure 3.2 Occupations of PhD graduates of 2003-2007 by academic discipline

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20 What do researchers do? Vitae, 2009. This is first destination data and only considers where postgraduates went to after graduating. It differs from the LFS data presented from the Roberts Review as the latter looks the economic activity rates of all SET postgraduates.
In terms of the employment sectors of PhD graduates of physical sciences and engineering, the findings of the 2003-2007 cohort were as follows.

- The education sector was the largest employer, with 42% taking up employment in this sector post-graduation. Of these, as many as 23% of the physical sciences and engineering cohort were working as postdoctoral researchers in academia.

- The two largest industry employment sectors were manufacturing (25%) and business, finance & IT (20%). The share for manufacturing is the highest across all disciplines (where the average is 14%) and, within this sector, the chemical and pharmaceutical industries accounted for a significant share. The finance, business & IT sector increased their share of these graduates between 2003 and 2007 from 18% to 21%. Given the economic crisis and its impact on these sectors, these trends may have changed, as the burden of jobs cuts and recruitment freezes have fallen on the private sector to date21.

- Other industry sectors attracted much smaller shares of physical sciences and engineering PhD graduates.

In contrast, a study by EPSRC in 2000 found that only 15% of their CASE studentship graduates went on to be employed in the private sector, which represents a significantly lower share than the above results.22

It is important to bear in mind that these results reflect the initial destinations of these graduates and not subsequent changes, e.g. they may chose to stay in academia for a time after graduating but then move on into industry.

In terms of occupation, the 2003-2007 destination results show that scientific R&D occupations was the largest occupational group of physical sciences and engineering graduates, with 23% classifying themselves in scientific R&D occupations. The second most common occupation was researchers (20%), and third was engineering professionals (12%). Figure 3.3 illustrates the results from this study.

Some of the occupation categories changed between the 2004 and 2009 Vitae first destination studies and it is therefore difficult to directly compare the results of the two studies. However, the largest change was recorded in the category of business and finance, which increased from 5.3% to 7.8%. This follows a similar trend to the employment sector destination results.

21 See recent paper from Confederation of British Industry (CBI) and Price Waterhouse Coopers [link]
The destination information for doctoral graduates of physical sciences and engineering indicates strong vocational ties to the subjects studied and researched compared to other subject groups. Almost three-quarters of the graduates have entered employment as researchers, engineers, teachers or technology professionals.

Table 3.1 shows the occupational destinations of all PhD disciplines. The occupations are ranked according to the results for physical science and engineering destinations. There are large variations across the disciplines, but the R&D professions are also heavily represented among biological PhD graduates. The percentage of physical sciences and engineering PhD graduates going into business and finance professions and, to an extent, also social sciences graduates, is higher compared to the other discipline groups but still relatively low in total terms.
Table 3.1 Occupational destination of UK domiciled PhD students by discipline

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Physical sciences and engineering</th>
<th>Arts and humanities</th>
<th>Social sciences</th>
<th>Biological</th>
<th>Biomedical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific research, analysis &amp; development professionals</td>
<td>22.9%</td>
<td>0.0%</td>
<td>0.7%</td>
<td>34.1%</td>
<td>14.1%</td>
</tr>
<tr>
<td>Researchers (university or unspecified)</td>
<td>20.2%</td>
<td>14.3%</td>
<td>18.6%</td>
<td>27.3%</td>
<td>14.3%</td>
</tr>
<tr>
<td>Engineering professional</td>
<td>11.8%</td>
<td>0.2%</td>
<td>0.0%</td>
<td>1.3%</td>
<td>0.6%</td>
</tr>
<tr>
<td>Education and teaching professionals</td>
<td>11.3%</td>
<td>46.6%</td>
<td>49.6%</td>
<td>9.8%</td>
<td>12.6%</td>
</tr>
<tr>
<td>Information technology professionals</td>
<td>7.8%</td>
<td>0.7%</td>
<td>0.2%</td>
<td>0.6%</td>
<td>0.3%</td>
</tr>
<tr>
<td>Business &amp; finance professionals and associate professionals</td>
<td>7.8%</td>
<td>3.5%</td>
<td>6.7%</td>
<td>5.0%</td>
<td>1.5%</td>
</tr>
<tr>
<td>Commercial industrial &amp; public sector managers</td>
<td>5.9%</td>
<td>6.6%</td>
<td>10.6%</td>
<td>4.4%</td>
<td>3.9%</td>
</tr>
<tr>
<td>Other professional, associate professional and technical occupations</td>
<td>5.5%</td>
<td>13.1%</td>
<td>6.0%</td>
<td>5.6%</td>
<td>8.6%</td>
</tr>
<tr>
<td>Marketing, sales, media and advertising occupations</td>
<td>2.5%</td>
<td>6.6%</td>
<td>2.0%</td>
<td>5.1%</td>
<td>1.2%</td>
</tr>
<tr>
<td>Numerical clerks and cashiers, clerical, retail and bar staff</td>
<td>2.2%</td>
<td>5.9%</td>
<td>3.1%</td>
<td>1.7%</td>
<td>0.9%</td>
</tr>
<tr>
<td>Other occupations</td>
<td>0.6%</td>
<td>1.5%</td>
<td>0.7%</td>
<td>1.1%</td>
<td>0.4%</td>
</tr>
<tr>
<td>Armed forces &amp; public protection services occupations</td>
<td>0.5%</td>
<td>0.3%</td>
<td>0.2%</td>
<td>0.2%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Health professionals and associate professionals</td>
<td>0.5%</td>
<td>0.5%</td>
<td>1.6%</td>
<td>3.7%</td>
<td>41.6%</td>
</tr>
<tr>
<td>Unknown occupations</td>
<td>0.4%</td>
<td>0.2%</td>
<td>0.0%</td>
<td>0.2%</td>
<td>0.0%</td>
</tr>
</tbody>
</table>

Source: Vitae, What do researchers do? 2009

3.3 Employment

This sub section considers the basis for employer demand for doctorate holders, the skills that they bring and barriers to employing them. This is important to consider in relation to impact as it helps to uncover the rationale for employers employing those with PhDs.
3.3.1 Employer demand

The demand for PhD students was investigated as part of a recent Irish study. A Business Expenditure on Research and Development survey (BERD) found that those companies that currently employ PhD researchers are more likely to forecast further recruitment of PhD students than those R&D companies that do not employ PhD students. This aligns with other results, which stated that those who currently employ PhD graduates are more likely to recruit and target new PhD graduates. This seems to suggest that those employers who employ PhD graduates are better able to recognise the skills of this group, being based on actual experience rather than perceptions. This was noted in previous reviews of the literature around impact of PhD graduates.

The BERD survey shows that, out of the firms currently employing PhD researchers, 61% stated that they intend to employ further PhD researchers before 2013, compared to only 18% of those who do not currently employ PhD students. By sector, the chemicals, instruments and pharmaceutical sectors were more likely to state that they will employ further PhD researchers, with around 75% of companies in this category.

Subsequent questions explored the preference towards experienced and newly graduated PhDs, and the overall results showed that companies have a preference to employ experienced PhD researchers rather than newly qualified researchers. However, the pharmaceutical, chemical and instruments sectors expressed the highest demand for newly graduated PhD candidates, with 72%, 64% and 47% respectively likely to employ more PhD graduates before 2013. Companies in the pharmaceutical sector were also found to make less of a distinction between experienced and newly qualified PhD researchers in their preferences. It may be that these employers have an interest in acquiring intellectual property rights for some of the developed ideas that these newly qualified PhDs may have.

These results show a positive market and strong demand for qualified PhDs in physical sciences and engineering in Ireland. Within the context of a global labour market and industry, we would expect similar characteristics to be found in the UK, along with other developed countries. The employer survey in Phase 2 did identify the importance of doctoral qualified staff for research intensive businesses and the positive impacts they generate, both internally for their employers and externally for government, suppliers, customers and society more generally: see Section 2 – ‘Impact of Doctoral Training’.

The destination results discussed earlier in Section 3 indicate that there is a strong pull towards research and engineering sectors, and that graduates of physical sciences and engineering are employed in sectors that are strongly linked with their academic subject area.

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24 The Role of PhDs in the Smart Economy, Forfas/Advisory Science Council, December 2009
A forecasting study was carried out in Australia for the Federal Department of Innovation, Industry, Science and Research, mapping likely future demand for PhDs. As with many of the UK sources, doctorate qualified individuals could not be identified as a separate group from postgraduate qualified individuals. A range of measures were drawn upon in the forecasting model and weighting was applied by the researchers to examine doctoral growth, thus producing indicative results. The forecasts of PhD demand demonstrate that this will continue to grow in the coming years, even with the recent economic decline.

“As can be seen in the workforce numbers, the doctorate degree-qualified workers make up a relatively small component of the overall workforce. However, importantly, the projections suggest that employment numbers for this level of education will experience the equal fastest growth among the education levels ... The total Australian workforce is expected to grow by 16.6 per cent between 2007 and 2020, but the doctorate degree level component of this workforce has a projected 47.9 per cent growth over this time.”

Where demand for individuals without post-compulsory qualifications is estimated to decline, demand for postgraduate qualified individuals is forecast to continue growing. Notably, the largest growth was predicted for the 20-34 age group, with the suggestion that this would help to ‘regenerate’ the ageing Australian academic workforce, which will need to grow in order to meet national targets for 40% of the 25-34 age group to have a Bachelors degree or higher.

When broken down by educational area and related industry, the largest proportionate growth came in areas such as political science and policy studies (at 84%) and law (at 70%). However, significant growth is also seen in the sciences, with natural and physical sciences seeing a proportionate growth of 66%, process and resources engineering at 53%, and engineering and related technologies at 43%.

Edwards argues that the results of this forecast model could be significantly higher, depending on the trajectory of federal policy in Australia, which is currently emphasising the knowledge economy and the need to shift national reliance from natural to human resources.

The UK is recognised to have one of the highest quality and most cost-effective science bases among the advanced countries. An Arthur D. Little report investigated the decisive factors influencing global firms deciding where to locate and make their R&D investments. Access to expertise and qualified staff was found to be a key determining factor for location of R&D, ranked as the most or second most important factor. Education is therefore essential in order to produce the scientists, technologists and engineers that provide a healthy base across subject disciplines, and the essential characteristics to attract investment and sustain R&D excellence.

26 Global R&D: Where to place the bets?, Arthur D. Little, 2006
3.3.2 Skills for employment

The Roberts Review suggested that PhD graduates were poorly prepared for eventual employment in either academia or business. It claimed that a PhD degree does not prepare students for careers and there is insufficient access to training in interpersonal and communication skills, management, and commercial awareness to benefit a modern business or teaching environment. It highlighted that these issues must be addressed or, in the longer term, this could affect the high-class research and development undertaken in the UK.

Similar discussions are taking place in Australia regarding the preparation of these highly skilled individuals for the world of work as part of a national higher education transformation programme.

Manathunga et al carried out a pilot study in Australia of the outcomes of research training for PhD graduates who studied science-related areas under the Australian Cooperative Research Centres (CRC) programme. The federal CRC programme was set up to enhance collaboration and cooperation between the university, government and industry settings. The researchers compared responses to a range of elements of research training across those on the CRC programme and those in a ‘school-based’ setting (e.g. more traditional PhD training). Interestingly, however, less than a third of the CRC programme respondents felt that the links that they had with industry as part of their PhD studies were beneficial. Furthermore, only 58% of CRC programme graduates felt that they had developed skills that prepared them for post-graduation employment, compared to 75% of school-based graduates. On the other hand, 22% of school-based graduates, as opposed to 5% of CRC graduates, had ‘required further formal training or study since completing their PhD’. In terms of the outcomes for these PhD graduates, even among the CRC graduates, relatively few were employed in private sector research (6% CRCs) and non-research positions (24% CRCs), and the majority of school-based graduates were employed in university (55% school-based) and public sector research (18% school-based) roles.

While there are concerns about PhD graduates’ employability and skills, the UK GRAD Programme study found that unemployment among UK PhD graduates is low at 3.2%, and they are 50% less likely to be in unemployment than first degree graduates. There is also evidence that PhD graduates have jobs that are more challenging or are in professional jobs. Very few such graduates (about 1%) were in junior roles.

A survey of employers’ attitudes to postgraduate researchers ranked the skills sought in PhD graduates in the following way:

29 What Do PhDs Do?, UK GRAD Programme, Careers Research and Advisory Centre, 2004
31 Survey of employer attitudes to postgraduate researchers, Prospects, August 2006
Employers surveyed as part of previous studies identified skills that they perceive PhD graduates hold or lack. These findings are based on qualitative descriptions or perceptions by employers and should be treated with caution as many of the respondents did not employ PhD graduates and based their answers on their own perceptions. Table 3.2 outlines these identified skills.

Table 3.2 Identified skills that employers perceive PhD graduates hold or lack

<table>
<thead>
<tr>
<th>Lacking skills</th>
<th>Held skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial awareness</td>
<td>Initiative, intellectual ability and capacity to work autonomously</td>
</tr>
<tr>
<td>Flexibility and adaptability</td>
<td>Those with industrial experience are considered to be highly commercially aware and showed great capacity to learn</td>
</tr>
<tr>
<td>Interpersonal skills, team-working skills and customer orientation</td>
<td>Maturity and enthusiasm</td>
</tr>
<tr>
<td>Over-qualified, overspecialised, narrowness of interest, lack of self management</td>
<td>Technical proficiency, specialist knowledge and problem solving skills</td>
</tr>
<tr>
<td>Specific aptitudes</td>
<td></td>
</tr>
<tr>
<td>High expectations in terms of salary and career progression</td>
<td></td>
</tr>
</tbody>
</table>

Source: Employers’ views of researchers’ skills - A comprehensive review of the existing literature into employers’ views of the skills of early career researchers, The Rugby Team, September 2007

A different survey of employer attitudes found that around two-thirds of the respondents had more negative aspects than positive in employing PhD graduates. It is unclear whether these views were based on perceptions rather personal experiences. Many of the barriers were focused on PhD graduates being over-specialised, inflexible, and not commercially aware. There is also a common perception that research experience in academia does not match research experience in industry. This latter finding is supported by DTZ’s employers’ survey presented in Section 4: ‘Doctoral Lifecycle’. There was strong demand for industrially relevant doctoral programmes involving research placements with employers. Examples include EngD and Case Studentships.
A recent survey carried out by CIHE, commissioned by the Department of Business, Innovation and Skills, examined employers’ attitudes to PhD applicants and the skills they offered to business34. More than 40 employers took part in the survey, represented by both industrial and business services sectors, large and small. Among these, seven out of ten employers differentiate PhD students from their pool of applicants. Out of these employers, PhD graduates’ subject specific skills, research and technical skills, and new ideas and innovation were valued the highest. Table 3.3 highlights the overall findings of the survey.

Table 3.3 The value of recruiting staff with doctorate qualifications according to employers

<table>
<thead>
<tr>
<th></th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Partly agree</th>
<th>disagree</th>
<th>Total (excl n/a)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject-specific specialist knowledge</td>
<td>62%</td>
<td>24%</td>
<td>6%</td>
<td>9%</td>
<td>34</td>
</tr>
<tr>
<td>Research/technical skills</td>
<td>56%</td>
<td>31%</td>
<td>6%</td>
<td>8%</td>
<td>36</td>
</tr>
<tr>
<td>Analytical thinking</td>
<td>58%</td>
<td>28%</td>
<td>8%</td>
<td>6%</td>
<td>36</td>
</tr>
<tr>
<td>Maturity</td>
<td>21%</td>
<td>32%</td>
<td>29%</td>
<td>18%</td>
<td>34</td>
</tr>
<tr>
<td>New ideas, help innovate</td>
<td>38%</td>
<td>35%</td>
<td>24%</td>
<td>3%</td>
<td>34</td>
</tr>
<tr>
<td>Guaranteed high calibre candidates</td>
<td>10%</td>
<td>26%</td>
<td>55%</td>
<td>23%</td>
<td>31</td>
</tr>
<tr>
<td>Future Leadership potential</td>
<td>9%</td>
<td>27%</td>
<td>50%</td>
<td>18%</td>
<td>34</td>
</tr>
</tbody>
</table>

Source: Talent Fishing – What Businesses Want from Postgraduates, CIHE report for BIS, 2010

There is strong symmetry between these findings and those of the DTZ employers’ survey, presented in Section 4: ‘Doctoral Lifecycle’. Our survey results demonstrate that research-intensive employers tend to rate research skills, problem solving, data analysis and communication competencies higher than broader based management and leadership skills.

The CIHE study categorised employers into four categories by the way they recruit postgraduates35:

1. ‘Trawlers’ – These are employers that do not specifically seek out postgraduates and treat them little or no differently from other applicants in the general recruitment process.

2. ‘Spearfishers’ – Employers that seek out postgraduates with specific skills to fill specific jobs. These employers often have good links and relationships with university departments, which help them to identify suitable prospective employees. This group of employers generally value and recognise the skills and specialist knowledge that postgraduates can bring to a post.

34 Talent Fishing – What Businesses Want from Postgraduates, CIHE report for BIS, 2010
35 Talent Fishing – What Businesses Want from Postgraduates, CIHE report for BIS, 2010
3. ‘Anglers’ – These employers often prefer to employ postgraduates as they expect these candidates to have additional skills and experience to first degree candidates. However, they do not restrict themselves to postgraduates and will employ beyond this group if suitable candidates appear.

4. ‘Harvesters’ – Employers who have multiple means of finding postgraduates to specific parts of the business, but also hire more generally beyond these specific needs.

There is also an additional fifth category, which do not employ postgraduates, because they see no value in a higher degree qualification. These employer categories were all clearly identifiable in the DTZ in-depth survey of employers, with a wide spectrum of approaches being adopted in the targeting and recruitment of doctorate holders: see Section 4 – ‘Doctoral Lifecycle’.

However, criticisms were also raised about postgraduate candidates, stating they had difficulty in adapting to non-academic environment, over-specialisation, lack of transferable skills, a lack of work experience and commercial awareness.

The CIHE survey results indicate that the PhD qualification is not perceived as a signal of a high quality candidate with future business leadership potential. The employers saw few distinctions between Masters and PhD qualifications, but, interestingly, the exception was in the engineering field, where PhD applicants were preferred.

These studies show that, generally, those employers that were actively recruiting postgraduate researchers were more likely to highlight the advantages of their skills and background. Many of the negative views are formed by employers not actively recruiting postgraduates, or were views are based on perceptions. However, some of the criticism applies to both groups of employers, for example the lack of commercial awareness among PhD graduates.

3.3.3 Barriers to employment

The Roberts Review found that there were barriers to entering employment for science, engineering and technology PhD degrees. The following two main reasons were given as to why graduates do not reach their full potential in the labour market during recruitment processes.

- Lack of opportunities to develop wider skills in academia.
- Inability of PhD graduates to articulate and recognise the transferable skills they have developed.

A study, in 1999, surveyed EPSRC funded PhD students and staff in receipt of research awards. It found that a large proportion of the staff perceived that PhD students lack a clear career path when graduating. A study investigating PhD recruitment found that the elements that attracted PhD graduates to industry included variety of work, shorter project timescales and greater job security. Career services, employers and PhD graduates were surveyed as part of the study and, in talking to the different groups, three common themes were found that could improve the recruitment of PhDs.

- Demonstrating understanding of the unique value of PhD graduates
  - Employers and career services that target PhD graduates should treat them as a distinct group, and acknowledge their research skills and high abilities.
- The need for further engagement and dialogue
  - There should be channels to increase the relationships and understanding between employers and graduates.
- The importance of communication mechanisms
  - A communication mechanism should facilitate the contact between employers and graduates.

The same study found that it was a common feeling among PhD graduates that employers are not effective enough in their ‘signalling’ to PhD students. There is often general graduate recruitment, but this channel does not differentiate undergraduate and postgraduate students, and it may be that many employers do not perceive them to be different. The study also found that finance and consultancy sectors appear to be the most proactive in their recruitment strategies towards postgraduates.

An Irish study on the role of PhDs in the national economy found that 48% of the surveyed companies that currently employ PhD candidates consider that the lack of availability of candidates with relevant knowledge of companies’ own research area is a barrier to PhD employment in industry. In addition, 28% said the lack of enterprise experience is another relevant barrier.

Employers surveyed in the UK stated that if applications are received from PhD graduates for vacancies that do not require postgraduate experience, they are often treated the same way as other qualified applications. However, some employers expressed concern about applications that do not reflect the same area of research or skills needed for the job. Others saw wider skills as more important, having the right competencies, communication skills and ‘fitting in’. Some had negative perceptions of PhD graduates and would therefore not consider these candidates. Such attitudes towards PhD graduates clearly represent significant barriers to employment and the best use of such graduates’ skills.

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37 Attraction & Retention of Staff & Students in Research in IT & Computer Science, Engineering and Physical Sciences Research Council. May 1999
38 Recruiting PhDs – What works? The UK Grad Programme, March 2007
39 However, this was not the case in a number of DTZ’s in-depth case studies. Employers that stated doctoral graduates were not a target clearly articulated their rationale for this. For example, a number of manufacturing employers recruit on the basis of merit irrespective of whether candidates have a postgraduate qualification. For them, a graduate will often be more valuable after three years in-house training with the business compared to employing a doctorally qualified graduate.
40 Recruiting PhDs – What works? The UK Grad Programme, March 2007
41 The Role of PhDs in the Smart Economy, Forfas/Advisory Science Council, December 2009
42 Survey of employer attitudes to postgraduate researchers, Prospects, August 2006
3.4 Impact

The figure below illustrates a classification framework for assessing the benefits from employment of PhD graduates. The sections below provide further analysis of these types of impacts. The overlap between the main impact categories implies that they are not mutually exclusive: for example, impacts that benefit individuals may also benefit their employers and wider society.

**Figure 3.4 Overview of impacts of PhD graduates**

![Diagram showing the classification framework for assessing the benefits from employment of PhD graduates.]

Source: DTZ

### 3.4.1 Individual impact

The Roberts Review stated that the average salaries for postgraduates, mainly PhD graduates, generally exceed those of non-graduates. This indicates a premium is paid for higher-ability and higher-skilled graduates.\(^{43}\)

O'Leary and Sloane modelled wages on the basis of education levels and showed that the lifetime wage premia increases as the education level rises.\(^{44}\) The table below highlights their findings. For both males and females, the wage premia are greater for doctorate graduates.

**Table 3.4 Individual lifetime wage premia of a university education in Great Britain**

<table>
<thead>
<tr>
<th>Degree</th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Undergraduate</td>
<td>0.2023</td>
<td>0.3549</td>
</tr>
<tr>
<td>Master's</td>
<td>0.2915</td>
<td>0.5400</td>
</tr>
<tr>
<td>Doctoral</td>
<td>0.3140</td>
<td>0.6002</td>
</tr>
</tbody>
</table>

Source: O’Leary & Sloane (2005)

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\(^{43}\) *SET for success: the supply of people with science, technology, engineering and mathematics skills*, The Report of the Sir Gareth Roberts Review, 2002

\(^{44}\) O’Leary & Sloane, *The Return to a University Education in Great Britain*, *National Institute Economic Review*, No. 193, July, 2005
However, they also found that the rate of return appears to be lower for engineering and technology PhD graduates compared to medicine and science based subjects (see Table 3.5, below). For men and women in engineering and technology subjects, the average rate of return lies between 3.5% and 5%. For sciences, this rate is between 7.9% and 14.2%, and for medicine it is as high as 14.6% to 17.8%. The precise reasons for these results are not known, but these figures should be treated with caution as the sample sizes for this analysis were relatively low for a number of the subject areas.

Table 3.5 Individual rate of return by PhD subject area

<table>
<thead>
<tr>
<th>Subject</th>
<th>n</th>
<th>Rate of return - Male</th>
<th>Rate of return - Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medicine and related</td>
<td>100</td>
<td>0.1781*</td>
<td>0.1459*</td>
</tr>
<tr>
<td>Sciences</td>
<td>528</td>
<td>0.0785*</td>
<td>0.1419*</td>
</tr>
<tr>
<td>Maths and computing</td>
<td>75</td>
<td>0.0478</td>
<td>0.1239*</td>
</tr>
<tr>
<td>Engineering and technology</td>
<td>131</td>
<td>0.0497</td>
<td>0.0350</td>
</tr>
<tr>
<td>Architecture and related</td>
<td>4</td>
<td>-0.0656</td>
<td>N/A</td>
</tr>
<tr>
<td>Social sciences</td>
<td>72</td>
<td>0.0750**</td>
<td>0.1427**</td>
</tr>
<tr>
<td>Business and financial studies</td>
<td>12</td>
<td>0.2021*</td>
<td>0.1080*</td>
</tr>
<tr>
<td>Arts</td>
<td>107</td>
<td>0.0448</td>
<td>0.0845**</td>
</tr>
<tr>
<td>Languages</td>
<td>9</td>
<td>0.0119</td>
<td>0.0662</td>
</tr>
<tr>
<td>Education</td>
<td>13</td>
<td>-0.0099</td>
<td>0.1239*</td>
</tr>
<tr>
<td>Combined</td>
<td>109</td>
<td>0.1116*</td>
<td>0.1507*</td>
</tr>
</tbody>
</table>

Note: * (**) statistically significant at 95% (90%) confidence level; baseline - first degree in that subject. Source: O’Leary and Sloane (2005)

The study also found that the rate of return for engineering and technology PhD graduates were less than the returns of Masters graduates in the same subject. It was suggested that this is a reflection that three years experience is often more highly regarded in technical and practical sectors than three or more years studying for a PhD. Although not specific for engineering and technology, a study by Warwick Institute for Employment Research confirms that returns to higher level 5 vocational qualifications (including graduate membership of professional institutes and other post-graduate professional qualifications) exceeded those to level 5 academic qualifications such as PGCEs and PhDs.45

Larkins, on the other hand, found that individual rates of return for science and technology in Australia were higher, at around 12%, and increased from Masters to PhD level.46 These rates were estimated to be higher compared to graduates of humanities and social sciences.

45 A study on rates of return to investment in Level 3 and higher qualifications, Warwick Institute for Employment Research, November 2005
Table 3.6 Individual rate of return of university degrees

<table>
<thead>
<tr>
<th>Specification</th>
<th>Masters (research)</th>
<th>Doctoral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Science and Technology</td>
<td>12.0%</td>
<td>12.7%</td>
</tr>
<tr>
<td>Humanities and Social Sciences</td>
<td>8.8%</td>
<td>10.4%</td>
</tr>
</tbody>
</table>

Source: Larkins (2001)

As highlighted previously, the skill area of engineering is increasingly a global one, especially with large worldwide employers and a high proportion of manufacturing being outsourced from the UK. Engineering is one of the global professions able to operate in a worldwide market. This may exert some downward pressure on the wage levels in the UK, despite the shortage of STEM skills. Both the commercial and academic STEM sectors in the UK have found it very difficult to compete with salaries offered by the financial services sector and, increasingly, graduates have been drawn to this sector.

Most of the employers surveyed as part of an analysis of PhD recruitment stated that they do not differentiate between undergraduates and postgraduates in their recruitment process, but had shortlisted people with PhDs through a general approach. However, some employers stated that they use a different recruitment route for PhD graduates and offer a higher starting salary. Many stated that they reflect the salary in the progression of new recruits and one company noted that this generally leads to PhD graduates earning a higher salary as, “PhDs seem to get promoted quicker.”

A study of employers’ views found that employers of engineering graduates, in particular, were more likely to directly target postgraduate researchers compared to other employers. They were also more likely to differentiate postgraduate employees from undergraduates in terms of career path and remuneration. This study also found that postgraduate researchers tended to learn quickly, therefore generating quicker promotions in terms of career and salary. This also indicates quicker return on investment for companies themselves, requiring less time spent on training, for example.

While some companies reflect the level of degree obtained in their salary structure for graduates and pay PhD graduates more than undergraduates, there are other companies that do not. However, there seems to be general agreement among the employers of PhD graduates that progression is likely to be quicker and, therefore, will eventually lead to a higher salary reflecting the level of degree. A separate study of employers’ attitudes also recognises this position and states that most employers recognised that progression for PhD graduates is quicker.

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47 STEM Review – the Science, Technology, Engineering, Maths Supply Chain, CIHE, March 2007
48 STEM Review – the Science, Technology, Engineering, Maths Supply Chain, CIHE, March 2007
49 Recruiting PhDs – What works? The UK Grad Programme, March 2007
50 Employers’ views of researchers skills - A comprehensive review of the existing literature into employers’ views of the skills of early career researchers, The Rugby Team, September 2007
51 Survey of employer attitudes to postgraduate researchers, Prospects, August 2006
Since the 1960s, a number of studies have focused on and analysed the private returns of higher education degrees, using human capital models and wage differentials to estimate the individual impacts.\textsuperscript{52} While social impacts have also been considered in some reviews, fewer studies have focused on the employer impacts.

### 3.4.2 Employer impact

The Leitch Review recognised that postgraduate skills levels are one of the most influential parameters for improving productivity.\textsuperscript{53} These higher skills are key drivers of innovation, entrepreneurship, management, leadership and research and development which, in turn, provide the right ingredients for a high performing and advanced economy. The higher skill levels are also important for promoting greater collaboration between industry and academia. DTZ’s survey of employers provides extensive and hard-hitting primary research evidence in support of the Leitch Review conclusions – see Section 2 – ‘Impact of Doctoral Training’.

SEMTA, the Sector Skills Council for science, engineering and manufacturing technologies, looked at career progressions for graduate recruitment as a whole in their sector. They found that highly skilled researchers were integral to the research and development in pharmaceutical and biotechnology companies. An older study, by UKCGE, noted that more PhD graduates were going into these industries, with companies targeting their recruitment at PhD graduates.\textsuperscript{54}

Jagger and Connor looked at Census and HESA first destination data and found that engineering PhD graduates were employed across most sectors in the UK.\textsuperscript{55} They also found that PhD and Masters engineering graduates were less likely to be unemployed than postgraduates of other subjects. Follow-up interviews with employees revealed that the key skills sought in PhD students are highly developed academic and problem solving skills, technical skills, business awareness and ‘soft’ skills. PhD graduates were perceived to be particularly skilled for consultancy and for generating good linkages with universities.

Importantly, for private research institutes, R&D functions and SMEs in the areas of science and engineering, PhD graduates were able to add weight in negotiations in terms of both technical and communication skills. PhDs were said to be an asset to an organisation by “adding to the [firm’s] credibility” and showing that they have leaders in their field.\textsuperscript{56}

\textsuperscript{52} Skills, Knowledge and Organisational Performance (SKOPE), University of Oxford
\textsuperscript{53} Leitch Review of Skills, Prosperity for all in the global economy, 2006.
\textsuperscript{56} Survey of employer attitudes to postgraduate researchers, Prospects, August 2006
A study that investigated PhD recruitment only included a small sample of employers, which gives some qualitative findings of employers’ views on the employability of PhD graduates. Almost all of the employers valued the PhD graduates for their communication and presentation skills as well as team work experience. Companies also benefitted from the technical and research skills of PhD graduates, meaning that they were at a much higher competency level than other graduates or experienced individuals, and could easily acclimatise to the necessary workload and level. Another important factor driving recruitment is when the specific skills and knowledge of a PhD graduate matches that of the company. 57

Employers also stated that candidates are often familiar with technology, techniques, methods or problem solving approaches. A number of other identified key skill sets were stated.

- The ability to communicate effectively in different settings and to people of different research backgrounds. In particular, their ability to digest and present technical information to a non-technical audience.

- High-level numerical skills are often sought by banking and finance industries, therefore these sectors often target PhD researchers in quantitative subjects such as physics, mathematics, engineering and computing. 58 As previously shown, the share of physical sciences and engineering PhD graduates going into these sectors is high compared to many other disciplines.

As part of a survey, respondents were asked if they observed any differences in the skill sets between recruited Masters and PhD graduates. Three-quarters responded that they had found no differences. However, it is worth highlighting that respondents were not always clear on people’s particular degrees and will not be looking for differences. In contrast, those that directly target PhD graduates from universities believe that they differ from undergraduates in terms of management skills, time and resource management. They are also considered to have specialist knowledge and maturity. 59

Interestingly, it was found that those employers or managers who recruited PhD graduates tended to have PhDs themselves. 60 Indeed, many of the employers we interviewed saw an advantage in involving existing staff with PhDs in the recruitment process of other PhD graduates. This signals that companies are targeting PhD graduates in their recruitment and that they want someone who fully understands the potential benefits of recruiting a PhD graduate to be involved. An employee with a PhD in a company therefore has the potential to unlock opportunities for others and promote the benefits of wider PhD recruitment. The employers who said that they did employ post-graduates made very positive comments about them as employees.

The study investigating PhD recruitment found that the specific skills of PhD graduates helped the career progression for PhD employees, but it also provided quicker opportunities for them in management roles (of staff and projects). 61 The identified benefits of recruiting PhD graduates, rather than those with first degrees, were as follows.

57 Employers’ perceptions of recruiting research staff and students, Prospect
58 Recruiting PhDs – What works? The UK Grad Programme, March 2007
59 Employers’ perceptions of recruiting research staff and students, Prospect
60 Recruiting PhDs – What works? The UK Grad Programme, March 2007
61 Recruiting PhDs – What works? The UK Grad Programme, March 2007
• Experimental experience – reducing the time and costs for training
• Equipment experience – increasing their confidence and ability
• Experience of conducting/writing literature reviews – particularly important for new research of techniques and subject areas
• Wider knowledge of subject – maturity in their understanding
• People skills – for working in small groups, wider teams, and with clients.

This study went on to conclude that while it has been recognised that PhD graduates bring benefits of specialist knowledge, research/analytical skills, future potential and maturity to their new employers, the last few years have seen more PhD graduates going into small and medium-sized companies. These employers have highlighted the benefits of the skills of their recruits as well as their ability to move and develop quickly with the organisation.

The BERD survey in Ireland showed that R&D active firms who have PhD employees demonstrate 2.5 times greater patenting levels than those firms that do not employ PhD graduates. The firms also have greater collaboration with higher education. The BERD data shows that 29% of R&D active companies employ PhD graduates, but these firms account for 70% of the R&D expenditure in Ireland. 62 While these are positive findings, it is not possible to determine whether the high levels of R&D expenditure is the reason why PhDs are recruited by these firms or whether it is employing PhD holders that is helping to generate the higher levels of R&D expenditure.

PhD employees also stimulate the ‘absorptive capacity’ of a company, whereby they improve the ability of a firm to learn about other technology advances. The ability to adapt new technology and science often depends on internal capabilities, and scientifically and technologically qualified members of staff facilitate this process. They take a ‘gate-keeping’ role, monitoring and identifying external information, and making it applicable and available to the firm and its other employees. This has been labelled as “Two faces of R&D”, and it is recognised that, on occasion, the absorptive capacity can be as important as innovation itself.

Companies that employ PhD holders also benefit from ‘technology exchange’. This is closely linked to absorptive capacity but focuses on taking advantage of technology transfer and exchange in a collaborative fashion. This is also important during development and change, to know what is available externally to the firm, i.e. ‘knowledge of knowledge’, and to have access to it through networks. Globalisation of research also means that connections with international networks are increasingly important, as is the ‘translation’ of this knowledge to the company’s specific needs. 63

In summary, the literature highlights that PhD students bring with them skills, working methods and networks that they can apply to the industrial environment. They have the ability to solve complex problems, conduct research and develop new ideas. Furthermore, they are seen as bringing rapid impact to their employing organisations, representing a good return on investment in staff recruitment and development.

62 The Role of PhDs in the Smart Economy, Forfas/Advisory Science Council, December 2009
63 The Role of PhDs in the Smart Economy, Forfas/Advisory Science Council, December 2009
3.4.3 Social impact

The social benefits of PhDs can be economic, for example in the form of higher tax revenues or increased economic growth through R&D driven technical progress. Many of the possible impacts to society are hard to quantify and, where estimates exist, these may understate the true value.

Larkins estimated the social rate of returns of science and technology degree holders in Australia. Table 3.7, below, shows his results. The social returns capture the cost to the state of subsidising higher education and the increased tax revenues from degree holders. The spillover is the effect of university research on wider R&D leading to economic growth. The study found that investment in bachelor and research degrees results in significant economic benefits for the individual and for the wider society.

The study also compared the social returns from a Masters degree to that of a Doctoral degree. The results show that there is either no effect or a reduction in the social rate of return between Masters and Doctoral degree holders when social impacts are considered. While the cost of the additional education is justified in terms of return on taxation, there is no associated uplift in the return following a Doctoral degree.

Table 3.7 Social rate of returns of university degrees

<table>
<thead>
<tr>
<th>Specification</th>
<th>Masters (research)</th>
<th>Doctoral</th>
</tr>
</thead>
<tbody>
<tr>
<td>S&amp;T social without spillover</td>
<td>5.2%</td>
<td>5.2%</td>
</tr>
<tr>
<td>S&amp;T social with spillover</td>
<td>11.1%</td>
<td>9.0%</td>
</tr>
<tr>
<td>H&amp;SS social without spillover</td>
<td>6.2%</td>
<td>7.2%</td>
</tr>
<tr>
<td>H&amp;SS social with spillover</td>
<td>10.7%</td>
<td>9.9%</td>
</tr>
</tbody>
</table>

Source: Larkins (2001)

The research outputs of PhD graduates also benefit the public sector through the formulation of Government policy in economic, social and medical sciences. The economic costs and foregone benefits of poorly informed policies can be substantial. The Research Council Economic Impact Group identified that the major direct research contributions of EPSRC funded PhD students are focused in three main areas:

- Physical infrastructure outcomes
- Virtual infrastructure outcomes
- Health care, education and creative & heritage outcomes.

The Economic Impact Group also recognised that there are indirect contributions via public policy formation, where:

- technology policy represents a major beneficiary; and
- sustainability, health and creative & heritage represent significant policy beneficiary areas.

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65 Increasing the economic impact of Research Councils, Advice to the Director General of Science and Innovation, DTI from the Research Council Economic Impact Group, 2006.
66 The Research Council Economic Impact Group, chaired by Peter Warry, was set up in 2006 by the Office of Science and Innovation to examine how the economic impact of Research Council activities could be improved.
Since the publication of the Economic Impact Group’s findings, the RCUK has explored research impacts within their research communities and have developed a toolkit called ‘Pathways to Impact’ (formerly known as ‘Impact Plan’). This toolkit details the potential impacts from academic research and recognises that there are two types of impacts: academic; and economic and societal.

‘Pathways to Impact’ outlines the following as potential societal impacts of research.

- Improving health and well-being
- Wealth creation, economic prosperity and regeneration
- Enhancing the research capacity, knowledge and skills of public, private and third sector organisation
- Changing organisational culture and practices
- Enhancing the effectiveness and sustainability of organisations including public services and businesses
- Improving social welfare, social cohesion and/or national security
- Enhancing cultural enrichment and quality of life
- Environmental sustainability, protection and impact
- Evidence based policy-making and influencing public policy
- Increasing public engagement with research and related societal issues.

DTZ’s employer survey and in-depth interviews provide strong supporting evidence for these conclusions on the wider economic, policy, environmental and societal benefits from doctoral level education: see Section 2: ‘Impact of Doctoral Education’.

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67 Research Councils UK: Pathways to Impact http://impacts.rcuk.ac.uk/default.htm
4. Doctoral ‘Lifecycle’ – the Employer Perspective

Key findings

Recruitment – the majority of employers (63%) actively target doctorate holders as part of their recruitment process in their organisation. Possible explanatory factors for those that do not actively target include:
- The fact that they are not actively recruiting at present, but may do so in the future
- Adverse economic factors impacting on their sector
- Global competition and off-shoring of research to lower cost locations
- Outsourcing research to academic institutions in the UK
- Rationalising research to a smaller number of corporate locations

CASE studentships are as important as standard PhDs.

Competencies – generic research competencies are rated most highly by research intensive employers. Four key research skills are rated as ‘very important’:
- Problem solving skills 75%
- Research skills/methodologies 63%
- Communication 59%
- Data analysis abilities 56%.

Progression – 92% of doctorate holders have the same or faster adaption times to their new roles on starting employment, in comparison with other graduate groups.

Conclusion – from the qualitative research findings, there are mixed messages on the level of demand for doctorate holders: some ‘big names’ are reducing their recruitment significantly, whilst others, including a number of innovative SMEs, are increasing their demand. However, the overarching finding from research intensive businesses is that a good quality supply of high calibre doctoral qualified staff from within the UK is of paramount importance due to:
- The contribution which doctorate holders play in supporting critical research functions across research intensive sectors such as automotive, pharmaceuticals, aerospace and IT;
- The important external benefits generated from investment in doctoral education, such as government policy, industry standards, health and environmental benefits;
- The impact which doctoral education has on the academic standing of the UK’s universities and research institutes. This is a ‘win-win’ or virtuous circle.

4.1 Introduction

This section presents DTZ’s analysis of the research findings derived from the following consultation exercises (a full list of consultees is presented in Appendix B):

- Phase 1 literature review (see Section 3 of the report)
- Phase 1 telephone survey of employers (19) and sector umbrella organisations (15) conducted by DTZ – the topic guide for the consultations is presented in Appendix C
- Phase 2 telephone and web-based survey of employers (126) conducted by Swift Research – the questionnaire is presented in Appendix F
- Phase 2 follow-up depth survey of 20 employers conducted by DTZ
In presenting our findings an integrated approach has been adopted, whereby the wide range of quantitative and qualitative data from these four research exercises have been analysed thematically against the headings in the PhD ‘lifecycle’ – see Figure 4.1.

**Figure 4.1 Analytical framework for employers’ survey**

Source: DTZ

Our analysis starts with the recruitment process at one end and finishes with the impact of PhD trained staff at the other end. However, as explained earlier, because of the importance of ‘impact’ to the study, we have presented this separately as a stand-alone write-up in Section 2.

Section 4 therefore focuses on the preceding elements within the PhD ‘lifecycle’. It is also worth noting that some employers may be involved with PhD graduates from an earlier phase, e.g. through scholarships and sponsoring. Where relevant, we have supplemented our analysis with findings from the umbrella organisations. Each element in the lifecycle is described below.

When presenting the quantitative survey results from the telephone and web-based survey of employers, we have cross-referenced the data to the question number in the survey (see Appendix F. Also, the full set of results is presented in Appendix G.

Additional qualitative feedback from employers and umbrella organisations is presented in Appendices D and E covering the demand and supply side perspectives respectively.

Prior to presenting the findings under the PhD lifecycle headings, we provide a profile of the respondents to the Phase 2 telephone and web-based survey. As this survey provides all of the quantitative primary research data in Sections 2 and 4, it is important to understand the profile of the achieved sample.
4.2 **Respondent profile**

**Sampling methodology** - the Phase 2 quantitative survey conducted by Swift Research was based on contacts provided by EPSRC. Drawing upon the findings from the Phase 1 pilot survey, there was a conscious effort to bias the employer sample towards organisations that were research intensive and/or likely to have a relatively high proportion of PhD graduates in their workforce. This sampling approach was justified as our pilot interviews with non-research intensive businesses and those employing few if any PhDs proved to be of limited value. Such employers found it difficult to enter into a meaningful discussion on the merits of doctoral education.

The consequence of this sampling methodology is that the sample is not representative so one cannot gross up the findings to the overall population of employers, nor can we draw any quantitative conclusions on impact at industry/sector level.

Furthermore, given the size and complexity of a number of the organisations consulted, the decision was taken by the client Steering Group to include multiple interviews from individual companies. Hence, for each question, the number of responses represents individual consultees, which is greater than the number of organisations consulted.

**Sample characteristics:**

*Sample Size* – 126 interviews were completed across 86 organisations, of which 76 agreed to reveal their identity. Given the number of multiple responses from some companies, a ‘cleaning’ exercise was undertaken to eliminate responses from within the same business unit. Hence, we only included responses from different subsidiary businesses and research units, with multiple entries from within the same business/research unit being merged into a blended response. This resulted in a sample size of 113 discrete responses across 86 organisations upon which our quantitative analysis in Section 4 is based.

*Sector* – the sample was drawn from four research intensive sectoral groupings: chemicals and life sciences, aerospace and defence, electronics/IT and automotive, which between them accounted for at least 86% of the sample – see Table 4.1. We have focused on these four sectors when analysing sectoral variations within the survey results.

---

68 'Chemicals and life sciences' includes pharmaceutical manufacturers and specialist niche laboratory businesses.
Table 4.1 – Sectoral Structure of Sample

<table>
<thead>
<tr>
<th>Sector</th>
<th>No. of Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemicals and life sciences</td>
<td>41</td>
<td>36</td>
</tr>
<tr>
<td>Aerospace &amp; defence</td>
<td>26</td>
<td>23</td>
</tr>
<tr>
<td>Electronics, IT and communications</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>Automotive</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>Public sector</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Other manufacturing</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Unknown*</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>113</td>
<td>100</td>
</tr>
</tbody>
</table>

Note: * ‘Unknown’ are those respondents who asked for the identity of their organisation to remain confidential, so we were not able to classify them by sector, although we were able to obtain other data from their questionnaires.

Source: DTZ

The rationale for focusing on these four sectoral groupings is supported by the fact that they account for nearly two-thirds of Business Enterprise Research and Development (BERD) in the UK:

- The pharmaceuticals product group alone represents 28% of all BERD spending in the UK.
- Other significant sectors include Aerospace (9%), Computer & Related Activities (9%), Telecommunications (7%) and Motor Vehicle & Parts (7%).

However, R&D only represented 11% of investment in innovation in the UK in 2007. Other main sources include product design, training in new skills, organisational innovation, developing new customer offerings and brands, and copyright.

Innovative businesses are most prevalent in the following industries by broad SIC code:

- Manufacture of Electrical and Optical Equipment – 77%
- Manufacturing Not Elsewhere Classified – 73%
- Fuels, Chemicals, Plastic, Metals & Minerals – 71%
- Food, Clothing, Wood, Paper Publishing & Printing – 69%
- Manufacture of Transport Equipment – 63%
- Real Estate, Renting & Business Activities – 62%.

In the manufacturing sector, it is the high technology industries that account for the substantial part of manufacturing BERD (around 65%). Therefore, again, there is a strong justification for targeting our sample on what high technology industries associated with both high R&D and high levels of innovation.

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70 NESTA, The Innovation Index – measuring the UK’s investment in innovation and its effects. November 2009.
72 OECD Science, Technology and Industry Scorecard 2009. These industries are made up of Pharmaceuticals; Office, Accounting & Computing Machinery; Radio, Television & Communication Equipment; Medical, Precision & Optical Instruments, Watches & Clocks.
Size – there was very significant bias towards consultees employed by large companies, with 50% of respondents being employed in businesses with more than 1,000 employees. Just over a quarter of the sample were from SMEs employing < 250 staff: see Table 4.2.

<table>
<thead>
<tr>
<th>Size Segments</th>
<th>No. of Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small &lt; 50 employees</td>
<td>20</td>
<td>18</td>
</tr>
<tr>
<td>Medium 50 – 250 employees</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>Large 250 – 1,000 employees</td>
<td>14</td>
<td>12</td>
</tr>
<tr>
<td>Very large &gt; 1,000 employees</td>
<td>56</td>
<td>50</td>
</tr>
<tr>
<td>Unknown*</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td>113</td>
<td>101**</td>
</tr>
</tbody>
</table>

Note: * ‘Unknown’ are those respondents who asked for the identity of their organisation to remain confidential, so we were not able to classify them by sector although we were able to obtain other data from their questionnaires.

** Does not sum exactly due to rounding.

Source: DTZ

Again, there is evidence at the UK level to justify an increased focus on large employers in the sampling methodology. For example, more than 80% of BERD in the UK is accounted for by large firms (250 or more employees)\textsuperscript{73}. Also, although the percentage of innovation active large companies (60%) is only 2 percentage points higher than SMEs, large companies are more likely to engage in most forms of innovative behaviour.

Ownership – the split between UK and foreign owned companies was almost a 50:50 split:

- UK owned businesses – 43%
- Foreign owned businesses – 46%
- Unknown – 11%.

Respondent perspective – the survey engaged almost exclusively with research staff, either technical or research management, who accounted for 90% of the sample: see Table 4.3.

<table>
<thead>
<tr>
<th>Role</th>
<th>No. of Respondents</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;D Management</td>
<td>74</td>
<td>65</td>
</tr>
<tr>
<td>R&amp;D Technical</td>
<td>28</td>
<td>25</td>
</tr>
<tr>
<td>Other</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>113</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: DTZ

Research profile – given that the survey targeted hi-tech sectors where innovation is the lifeblood of their business, it is not surprising that the respondents rated ‘research and innovation’ in their organisations to be of paramount importance:

- 96% of respondents rated research and innovation to be either ‘essential’ or ‘important’ for the development of products and services
- 82% of respondents rated research and innovation to be either ‘essential’ or ‘important’ for the development of processes.

\textsuperscript{73} OECD, op cit.
Examples of the Importance of Research

“Clearly, it is crucial to have PhDs who are trained up in, for example, medicinal chemistry, pharmacology, and pure biological research. Without this academic training, our organisation would not exist as a research organisation.”

“Research is essential for our company, reflecting the hi-tech nature of the industry and the importance of new product/process development. The R&D team acts as a specialist centre supporting the different production companies across the business.”

“Research and innovation is core to our company, therefore we need to have people at the top of their profession in these disciplines.”

“We are a contract research and development company. In other words, our product is research and development for industrial clients all over the world. Thus it is essential that we are at the cutting edge of R&D. Half of our annual new intake is usually at post-doctoral level.”

“Research is the foundation of a pharma company and we are no exception.”

“[In financial services], you have managers who are innovating structured products and highly engineered funds, which have a high degree of research content. In the industry in general, you have research into securities and into companies, which is an embedded research activity within the business.”

Interestingly, there is a significant variation when one analyses the results by sector. The percentage of respondents rating research and innovation in product and service development as ‘essential’ varied from 90% of chemicals/life sciences sector to 65% for aerospace and defence: see Table 4.4.

<table>
<thead>
<tr>
<th>Sector</th>
<th>Respondents rating research as ‘essential’</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No.</td>
</tr>
<tr>
<td>Chemicals &amp; life sciences (n=41)</td>
<td>37</td>
</tr>
<tr>
<td>Automotive (n=15)</td>
<td>12</td>
</tr>
<tr>
<td>Electronics, IT and communication (n=16)</td>
<td>11</td>
</tr>
<tr>
<td>Aerospace &amp; defence (n=26)</td>
<td>17</td>
</tr>
</tbody>
</table>

Source: DTZ

Foreign owned companies also rated research and innovation to be more important to their business than UK-owned companies; the respective figures being 85% versus 71% rating it as ‘essential’.
4.3 Recruitment

Recruitment Process – the literature review in Section 3 identified a study which found that those employers or managers who recruited PhD graduates tended to have PhDs themselves. Indeed, many of the case study organisations saw an advantage in involving existing staff with PhDs in the recruitment process of other PhD graduates. This signals that companies are targeting PhD graduates in their recruitment and that they want someone who fully understands the potential benefits of recruiting a PhD graduate to be involved. An employee with a PhD in a company therefore has the potential to unlock opportunities for others and promote the benefits of wider PhD recruitment. The employers who said that they did employ post-graduates made very positive comments about them as employees.

Targeting Doctorate Holders – the majority of organisations consulted actively target doctorate holders as part of their recruitment process: see Figure 4.2:

- 63% target at the level of the organisation as a whole; and
- 57% target at their own group/division.

These figures are somewhat lower than we expected given the hi-tech and research intensive nature of the organisations consulted. Possible explanatory factors for those that do not actively target doctorate holders, obtained from the qualitative research, include:

- The fact that they are not actively recruiting at present, but may do so in the future – in other words this could be a temporary rather than permanent position
- This could be explained by the economic downturn in the global economy, as a result of which companies are static or contracting in terms of their UK operations
- The restructuring of many industries and global businesses whereby they are off-shoring their R&D to locations such as Asia; and rationalising their international research base to a smaller number of locations
- A switch away from doctoral recruitment towards building relationships with academic partners in the UK and outsourcing the required expertise. This could result in a zero sum outturn in terms of the net demand for doctorate holders in the UK.

However, what we can say with a degree of certainty is that there is significant ‘churn’ and flux within the UK market for doctorate holders at present. Some of the big employers are reducing their demand due to downsizing and/or outsourcing. However, there are compensating movements from other high technology businesses – both large players and highly innovative SMEs – which are increasing their demand. Determining where the exact demand curve lies is not possible for a study of this nature.

Analysis by sector shows a marked variation in the active targeting of doctorate holders between chemicals/life sciences and electronics/IT at 81% and 75% respectively, compared to the aerospace and automotive sectors at around 40%: see Table 4.5.

74 Recruiting PhDs – What works? The UK Grad Programme, March 2007
Analysis by employer size also shows a marked variation between very large employers, where just over 50% of the sample actively target doctoral qualified staff, compared to SMEs, where the figure is 81% (the combined figure for small employers at 75% and medium sized employers at 91%). Intuitively, one would expect very large employers to be very active recruiters of doctoral qualified staff, but the qualitative feedback from the in-depth interviews conducted by DTZ provides evidence that the recruitment policies for some of the ‘big players’ has changed.

**Figure 4.2 – Targeting of Doctorate Holders (Q.5 i & ii)**

<table>
<thead>
<tr>
<th>Organisation as a whole</th>
<th>Yes, actively target</th>
<th>Yes, actively target for specific jobs/roles</th>
<th>No, do not specifically target but a doctorate might help someone be recruited</th>
<th>No, a PhD makes no difference in recruitment</th>
<th>Don't know</th>
</tr>
</thead>
<tbody>
<tr>
<td>18%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Your group/division</th>
<th>Yes, actively target</th>
<th>Yes, actively target for specific jobs/roles</th>
<th>No, do not specifically target but a doctorate might help someone be recruited</th>
<th>No, a PhD makes no difference in recruitment</th>
<th>Don't know</th>
</tr>
</thead>
<tbody>
<tr>
<td>20%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1%</td>
</tr>
</tbody>
</table>

Source: DTZ

In some of the other industries that we examined in the qualitative research, there was also seen to be a need to recruit doctorate holders, for example in financial services.

<table>
<thead>
<tr>
<th>Table 4.5 – Active Targeting of Doctoral Qualified Staff by Sector &amp; Employer Size</th>
<th>Respondents involved in ‘active’ targeting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sector</td>
<td>No.</td>
</tr>
<tr>
<td>Chemicals &amp; life sciences (n=41)</td>
<td>33</td>
</tr>
<tr>
<td>Electronics, IT and communication (n=16)</td>
<td>12</td>
</tr>
<tr>
<td>Aerospace &amp; defence (n=26)</td>
<td>11</td>
</tr>
<tr>
<td>Automotive (n=15)</td>
<td>6</td>
</tr>
</tbody>
</table>

| Size (employment number)                                                        | No.                      | %                      |
| Small < 50 staff (n=20)                                                         | 15                        | 75                      |
| Medium 50 – 250 staff (n=11)                                                     | 10                        | 91                      |
| Large 250 – 1,000 staff (n=14)                                                   | 9                         | 64                      |
| Very large > 1,000 staff (n=56)                                                  | 30                        | 54                      |

Source: DTZ
Importance of Recruiting Doctorate Holders in Financial Services

“In our industry, there is a strong need for highly competent ‘quants’ to work at the mathematical and modelling end of our business. This, in particular, relates to risk management, which is an increasingly important area post-crash. There is strong recruitment into risk spaces where modelling with the construction of ‘quants’ models is a core competence. It tends to be the case that those who are recruited are PhD mathematicians or heavy ‘quants’ PhD physicists.

There are some other areas that are associated with risk, i.e. structuring, hedging, portfolio construction and asset allocation, where, again, the industry would go to a research qualified and highly quantitative market.”

The CIHE (2010)\textsuperscript{75} study classified employers into four main categories by the way they recruit postgraduates (see literature review in Section 3). From the in-depth interviews conducted by DTZ, we can confirm that this classification system ‘holds’. For the research-intensive employers we consulted, we have been able to rank the recruitment categories in order of importance (1\textsuperscript{st} is the most important and 4\textsuperscript{th} least important):

1. ‘Spearfishers’ – the targeting of specific doctorate holders with the relevant engineering and technical skills for the job. This is the most prevalent recruitment practice amongst research-intensive employers.
2. ‘Harvesters’ – employers who have multiple means of finding doctorate holders, but also hire more generally beyond this specific needs.
3. ‘Anglers’ – the additional competencies of doctorate holders are recognised, but they do not restrict themselves to them and will employ beyond this group if suitable first degree or other postgraduate candidates appear
4. ‘Trawlers’ – employers do not specifically target doctorate holders and treat them no differently in the recruitment process – this is the exception rather than the rule for the employers consulted, although the in-depth interviews did identify some cases.

Types of Doctorates – for those employers that are actively targeting doctorate holders, they are very discerning in the ‘type’ of doctorate they are looking for. In particular, there is strong demand for industrially relevant doctoral training, where students have been actively engaged in delivering industry-relevant research through CASE studentships and EngD courses – see Figure 4.3:

- 43\% of respondents target standard PhDs
- 42\% of respondents target CASE studentships
- 26\% of respondents target EngD and Doctoral Training Centre qualified staff.

These figures highlight that a significant proportion of companies target CASE studentships and EngDs. Targeting standard PhDs can be undertaken fairly easily, e.g with a well-worded job advertisement, but targeting CASE studentships and EngDs requires much more effort from an organisation to engage with a student and their research throughout a period of time, and then work to recruit them into their organisation.

\textsuperscript{75} Talent Fishing – What Businesses Want from Postgraduates, CIHE report for BIS, 2010
Definitions

**CASE Studentship** – this is a PhD studentship during which the student enhances their training by spending between 3 and 18 months with their CASE partner in a workplace outside the academic partner. CASE studentship ‘programmes’ are core funded by the Research Councils and are awarded competitively. The advantages are shared by each of the three partners:

- The academic institution benefits from commercial and research linkages with their industry partner
- The doctoral student benefits from real-world applied research which is relevant to industry
- The employer benefits from the research expertise and inputs delivered directly by the student and indirectly via the host academic institution.

**EngD** - the Engineering Doctorate scheme is a British postgraduate education programme promoted by the UK’s Engineering and Physical Sciences Research Council (EPSRC). The programme is undertaken over four years. Students conduct PhD-equivalent research and undertake taught business and technical courses whilst working closely with an industrial sponsor on project based work relevant to the sponsor and the student. Successful candidates are awarded the degree of Doctor of Engineering (EngD).

**Figure 4.3 – Targeting of Doctorate ‘Types’ (Q.6a)**

![Bar chart showing percentage distribution of different types of PhDs](source: DTZ)
Examples of Targeted Recruitment of Doctorally Qualified Staff

“We participate in both CASE Studentships and we sponsor EngD students. Understanding the respective merits of both is important in managing our academic interface and engagement with doctoral students:

- **CASE** – this is more suitable for the laboratory end of our research spectrum – at the molecular level – understanding the material – more fundamental science. Suitable for exploring a research area where the focus is on enhancing knowledge and understanding; rather than having an immediate direct commercial application. However, being linked to industry, it helps the CASE students understand the wider commercial context.

- **EngD** – suitable for more applied research where the student spends a significant proportion of their time in industry. Here, the focus is on commercial application. The research focus includes equipment processing, variables in materials and process contribution to end product.”

“Targeted Recruitment – our approach is through the sponsorship of students:

- Supporting the Doctoral Training Centre at the University of Warwick
- Sponsoring CASE studentships
- Sponsorship of PhDs in selected universities.

Our company has a policy of recruiting the students that we sponsor. We also target our recruitment down to very specific technologies and know-how: for example, sensors and sensor fusion. We therefore target specific universities with the required know-how.”

“The most effective targeting is done through word of mouth, e.g. through the universities to establish likely candidates for recruitment. However, the company also uses recruitment agencies. Those who have had some industry exposure tend to be better prepared.”

Examples of Passive Recruiters of Doctorally Qualified Staff

“We have not been recruiting permanent staff for 8 years, although this position has changed in recent months as the company had been placing too much emphasis on agency staff. Therefore there has been no graduate or PG intake in recent years. There has been no CASE award for 3 years as there have been fewer funds for research.

EngDs have been taken very seriously (probably more so than PhDs) in recent years. The future focus of the company will be more on EngD recruitment. The advantages of EngDs include the possibility of more sponsorship (e.g. from the EPSRC), they are more closely aligned to the business, they can solve business problems while studying, and they can help to develop closer relationships with universities and academics. EngDs therefore tend to have greater commercial awareness and require less training.”

“There is some targeting of PhD qualified staff in the recruitment process, but it is really relevant industrial experience that we are after. There is not much recruitment at present due to low staff turnover and redundancies. The job adverts will be customised to the job opportunity and can specify MSc or PhD, however, experience from another firm can be more important.”
“There has been a recruitment freeze in our company. We are now more likely to pick a project and work with an academic rather than recruiting a CASE studentship. For example, we are no longer undertaking our own research in the UK and, instead, outsource the work overseas. This approach is much more selective and linked to our business interests. The downside of this approach is that this undermines the UK’s research capability in the long term, especially in the more fundamental areas of research that the academic institutions are best placed to contribute.”

Other Demand Drivers – from the umbrella organisations’ perspective, there were a range of conflicting factors believed to be impacting on employers’ demand for PhDs and their recruitment policy.

- Cost of recruitment – SMEs are put off recruiting PhDs because they are seen as “high maintenance” and requiring a level of development support that is disproportionate to the benefits.

- Drive for quality - Quality control issues are driving a number of employers towards increasing their recruitment of PhDs.

“For scientific and research intensive companies it is extremely important that their work is done properly. There is increasing scrutiny in the workplace so employers need to be sure that the employee is doing a good job. An employee who makes mistakes can cost a company a lot of money, so they are prepared to pay extra to get someone with a PhD in order to minimise this risk.”

4.4 Competencies

Given the research focus of the organisations surveyed and the research responsibilities of those consulted (90% of the sample had research responsibilities), it is not surprising that the competencies they rated most highly in doctorate holders are those related to the execution of a research function as opposed to wider business skills: see Figure 4.4. One can see the clear dichotomy between these two groups of competencies:

- Generic research related competencies assessed to be ‘very important’ rate very highly
  - Problem solving skills 75%
  - Research skills/methodologies 63%
  - Communication 59%
  - Data analysis abilities 56%.

- In contrast, more specific research knowledge related to PhD subject/area and the more generic competencies related to business, management and leadership that are assessed to be ‘very important’ are in most cases rated much lower:
  - Leadership/leadership potential – research/technology 43%
  - Understanding of broader subject of PhD 42%
  - Expertise specific to PhD 36%
  - Ability to network 31%
The qualitative feedback from the in-depth telephone interviews confirmed this dichotomy. Most research-intensive employers are looking to employ 'trained researchers' with a core toolkit, which enables them to tackle varied research assignments and problem solving with a high level of autonomy. Interestingly, expertise specific to their PhD is often not that important – rather the ability of the individual to 'get up to speed' quickly in what are often bespoke technologies unique to the sector or employer. “The benefit of PhD trained staff is not the technical knowledge per se, but rather the training it gives them.”

Figure 4.4 – Importance Rating of Competencies for Doctorate Holders (Q.8)

The literature review in Section 3 also confirms the importance of ‘technical and research skills’ to employers. For example, the CIHE study (2010)\textsuperscript{76} surveyed 40 employers and of the 70% that targeted PhD qualified staff, the most important competencies were:

\textbf{% Strongly Agreeing}

- Subject-specific specialist knowledge: 62%
- Analytical thinking: 58%
- Research and technical skills: 56%

\textsuperscript{76} Talent Fishing – What Businesses Want from Postgraduates, CIHE report for BIS, 2010
Of all the competencies listed in Figure 4.4, the one that is most sensitive to sectoral variation is 'Research Skills and Methodologies', with chemicals and life sciences rating this more highly: see Table 4.6.

<table>
<thead>
<tr>
<th>Sector</th>
<th>Respondents rating competence as ‘very important’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemicals &amp; life sciences (n=41)</td>
<td>No. 32</td>
</tr>
<tr>
<td>Automotive (n=15)</td>
<td>% 78</td>
</tr>
<tr>
<td>Electronics, IT and communication (n=16)</td>
<td>No. 9</td>
</tr>
<tr>
<td>Aerospace &amp; defence (n=26)</td>
<td>% 60</td>
</tr>
<tr>
<td>Source: DTZ</td>
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</tbody>
</table>

Examples of the Importance of Doctoral Research Competencies

“When we bring them into the lab for the first time, we expect them to hit the ground running. They are much more attuned at how to get from A to B quickly and cost effectively. The core competencies include:

**Technical skills**

- How to get information quickly
- How to conduct experiments
- How to analyse and deduce the key conclusions
- How to deal with the vagaries of data and handling ‘grey data’ – it is usually not black and white
- How to deliver timely results – picking the right experiments, accessing the most cost effective data and deriving the right scientific conclusions on time.

Non-PhDs require a lot more coaching – they lack the fundamental understanding of scientific research.

**Softer Skills**

Aspects such as leadership, management, business and commercial awareness are less important in their initial scientific roles. However, in later years, they are important and our firm develops these in the workplace supplemented with formal training.”

4.5 Training

If an organisation is recruiting doctorally qualified staff then, as described above, there is an expectation that they come with a set of core competencies relevant to their research role. The implication is that such team members should ‘get up to speed’ quicker and more effectively than non-doctorally trained staff. As illustrated in Figure 4.5, 38% of respondents believe that it takes less time for doctorate holders to adapt to their roles. The corollary is that they require less training and one-to-one supervision compared to non-doctorate holders.
This survey evidence was supported by the findings from our follow-up in-depth interviews, which highlighted the following two-pronged training approach:

- **Research skills** – in the majority of cases, minimal formal training is provided other than on-the-job mentoring, team work and conferences/seminars; and

- **Business skills** – more generic business skills are perceived to be much weaker and these are addressed through more formal training programmes, often further down the career path of the researcher. For example, if they have an interest in, and aptitude for, management and leadership then suitable training will be provided at the appropriate time in the career path of the individual.

**Examples of the Training Requirements for Doctorate Holders**

“No technical training is given. Staff are expected to know how to work in a lab and conduct scientific research. However, PhD holders do lack the skills needed to deal with customers; this is something that the staff need to work on when they join. Business/commercial sector knowledge does not come naturally to PhD holders, but it is something that they can learn. The firm provides inter-personal training, which greatly helps with this.”

“On-the-job training is provided: PhD holders are expected to be able to go into a job and require little technical training.”
“PhDs are expected to be able to work independently and need much less training than, say, graduates.”

“No formal training, but will provide on-the-job training in communications, interpersonal skills etc.”

“We have a suite of training modules, from science to leadership. However, these are not bespoke for PhDs and there is no specific programme for them. Instead, training will be provided internally at Department level on a bespoke basis to meet their requirements in terms of science, leadership, etc.”

‘Direct Entry’ vs. Graduate Recruitment
A number of employers made the distinction between ‘volume’ graduate programmes, where they go out into the market place annually to recruit ‘x’ number of graduates. This structured recruitment programme, with formalised induction and training programmes for the graduates, is quite different from their ‘direct entry’ route, which applies to ‘one-off’ entrants that are assessed on a case-by-case basis. Typically, this involves the recruitment of staff who join with experience from other employers and whose training requirements are generally catered for on a ‘lighter touch’ and bespoke basis. PhDs recruited from university are often included within this ‘direct entry’ category as demonstrated by the examples below.

“Recent [under]graduates spend 18 months going round the company on starting, finding out about the different departments and activities. Direct entrants, like PhDs, need a shortened version of this on employment, but it depends on the skill line.”

“We do not provide a generic training programme for PhD graduates when they join the company. Their training support is no different from what would be provided for other direct entrants. If necessary, a training programme is developed to meets the needs of the individual and the job they are fulfilling.”

Notwithstanding the above training philosophy for doctorate holders, there were examples of industry led initiatives to support both pre-docs and post-docs. For example, the pharmaceutical sector in the UK has been involved in building ‘training bridges’ between industry and academia:

Formal Training Models in the Pharmaceutical Industry
“We are working more on pre-competition training, collaborating with a number of companies and academic bodies and sharing resources. Examples include:

- **EMTRAIN**, part of the education and training arm of the Integrated Medicines Initiative (IMI), a European model of training for those working in the pharma industry. Big pharma companies help to develop the courses and provide resources in-kind. The training is meant to be personalised according to the needs of individuals, including those doing PhDs.

- **Doctoral training centres** are another good example of this. These are quite unique in the UK and there is now interest in this type of model from Europe. They are a way of generating both discipline excellence and collaborative behaviours.
A barrier to this approach is the time that people have to take out to do the training. This is more difficult for those employed in SMEs as they have less capacity to train staff compared to big pharma companies.”

The example, below, from the aerospace sector provides a good model of collaborative pre-competitive research between a number of leading companies in this sector. Not only does it help train doctoral students, but it provides direct learning benefits for the participating companies and the staff involved:

**Aerospace CASE – Imperial College London**

This multi-disciplinary approach to CASE studentships was led by Imperial College London, with strong support from its industrial partners. Several overlapping CASE studentships were funded to work on a common technology and application, but from different technical disciplines. Hence, one student focused on aerodynamics, one on materials and one on the mathematics of control theory, etc. Joint reviews with the industrial partners were held at frequent intervals and this was considered to be a highly effective inter-disciplinary model which closely mirrored operations within industry.

### 4.6 Progression

For research intensive functions, the expectation is that, in general, the rate of career progression for doctoral qualified staff will be at least comparable to, if not faster than, non-doctoral qualified staff. This conclusion is based on the following evidence:

- The 92% of respondents who consider that the ‘adaption time’ for new doctoral recruits is similar to, or faster than, non-doctoral recruits – see Figure 4.5.
- The 54% of respondents who have doctoral recruits working at middle management within 2 – 4 years – see Figure 4.6.
- The 51% of respondents who have doctoral recruits working at senior management within 5 – 10 years – see Figure 4.6.
**Example of Career Progression in Research Intensive Organisation**

*Matrix Team Leadership - Virtual Teams*

“We have a much flatter organisational structure now, with fewer managerial positions. However, we would expect a doctorate holder to be leading short to medium term research projects within 3 – 4 years of joining the company. This matrix management team leadership role demands networking and leading team members from within its global team. If the clinical trials are successful, then the leadership roles can last for up to 5 – 6 years.”

*Middle Management – Permanent Teams*

“Formal line management and leadership of ‘fixed’ teams of around 3 – 5 staff would involve all of the normal line management responsibilities and this is likely to be within 5 – 10 years of joining the company.”

*Senior management*

“This involves responsibility for larger functional areas and would normally apply after around 10 years. The company has about 20 management positions: 14 scientific and 6 non-scientific. In virtually all cases, the scientific management positions are led by doctorate holders, whereas, for the non-scientific roles, this is the exception rather than the rule.

There is a lot more qualitative evidence from the in-depth interviews reinforcing this finding. For research based employers actively recruiting doctorally qualified staff, there was an almost unanimous agreement that the doctoral qualification and associated experience was a ‘passport’ to more rapid and effective progression to Team Leader grade and beyond compared to other graduate groups. In summary, it facilitates:
• port of entry to the organisation is higher (larger job size);
• ‘passport’ to promotion;
• progression faster and higher;
• first to Team Leader grade; and
• technical skills combined with communication skills as a fast-track to success.

However, the counterpoint is equally true for those employers that are not research focused or who do not prioritise doctoral recruitment because they outsource this function.

Examples of Faster Career Progression for Doctorally Qualified Staff

“PhDs open doors for people. People start at a higher level and can progress in their career quickly. I would never have got to this position without having first had a PhD.”

“PhDs start at a higher level than graduates and need less on the job training so they can move up the ladder quicker.”

“PhDs can aspire to be a Fellow in our organisation, with a focus on project and people management, or a Chief Engineer on a leading specialism.”

“PhD qualified staff tend to achieve faster progression up the career ladder, e.g. they become Team Leaders quicker than those going through the Graduate Scheme.”

“We do have a salary increment for PhD level recruits, but, thereafter, career progress is up to the individual. Although we do not impose PhD requirements for progress beyond any particular level, PhD recruits do indeed tend to progress further and more quickly.”

“PhD holders have a ‘passport’ to career progression, particularly if they can combine their technical skills with good communication skills. Normally, PhD holders will be placed at a higher level than graduates and will go straight into team leader positions. They then tend to progress quickly. It is expected that PhD employees will be at a higher level – they are used to more responsibility and freedom to work.”

“It is the norm for PhD graduates to fill the Team Leader roles in research – it is the route to career progression in the company.”
Examples of Similar/Slower Career Progression for Doctorally Qualified Staff

“I wouldn’t say progression is faster or slower in our organisation. The way our system works is that it doesn’t really matter what your background is. What matters is the competencies you are executing and showing now. Some people do a doctorate because it’s right for them at that time. Others come into industry and get some experience, and then go into research. It’s very difficult after a few years seeing the difference. It’s all about what competencies they are displaying now – that’s how we move them through the system. If you look at our board/senior managers, there is a mixture between those with doctorates and those without. They have come through slightly different paths.”

“The career in the organisation is about getting to principal scientist role first of all and then onto senior scientist roles. At more senior levels in the company, it is an advantage to have a PhD, but there are no barriers as such (it is not a pre-requisite).”

“The skills demanded of staff are changing and continue to change. Instead of the discipline of detailed research and analysis, our company is looking for broad-based experience and the ability to engage comfortably across different disciplines and skill areas. This requires competencies such as good team working and the provision of mutual support. PhDs are often not comfortable with ‘going wide’. Industry experience is now more important to us than the training and discipline which a PhD degree confers. We can get better value from recruiting a graduate and mentoring them for 3 years compared to employing a postdoc.”

“The rate of progression depends on the staff member. Some PhD qualified staff will progress quite quickly, but others will prefer to stay in a research function and not progress to management. There are opportunities for everyone to climb the management ladder.”

Finally, a study profiled in the Section 3 literature review found that the specific skills of PhD graduates helped the career progression for PhD employees, but it also provided quicker opportunities for them in management roles (of staff and projects). The identified benefits of recruiting PhD graduates, rather than those with first degrees, were as follows.

- Experimental experience – reducing the time and costs for training
- Equipment experience – increasing their confidence and ability
- Experience of conducting/writing literature reviews – particularly important for new research of techniques and subject areas
- Wider knowledge of subject – maturity in their understanding
- People skills – for working in small groups, wider teams, and with clients.

This finding endorses the competencies sought by employers as outlined earlier in Section 4.

77 Recruiting PhDs – What works? The UK Grad Programme, March 2007
5. Summary and Conclusions

This final section summarises the key findings of the research and draws together a number of overarching conclusions based on analysis of the results from the different strands of evidence.

5.1 Summary of main results on impact

Below, we summarise the main results/findings on the impact of doctoral graduates, the main focus of the research.

- The majority of employers in research intensive organisations actively target doctorate holders as part of their recruitment process in their organisation. Doctorate holders are recruited by organisations because of the skills that they bring. This raises the capability of the organisations.

- **Direct impacts** are the most highly valued by the organisations. The main direct impacts sought are technical expertise, innovative/creative thinking, and problem solving and trouble shooting.

- However, achieving indirect impacts are also seen as very important. The main **indirect impacts** sought are improving team working, networking and absorptive capacity (the ability to learn from technological advances).

- It is the generic research competencies of doctorate holders that are rated most highly by research intensive employers. Four key research skills are rated as ‘very important’: problem solving skills; research skills/methodologies; communication; and data analysis abilities.

- Doctorate holders are also recruited to raise R&D capacity in organisations through their recruitment, training and development of staff. They have the potential to become future leaders in organisations: in around half of the sample, those with doctorates are anticipated to be able to reach middle management within 2-4 years and senior management within 5-10 years.

- Nearly all employers in our survey agreed that doctorate holders have the same or faster adaption times to their new roles on starting employment, in comparison with other graduate groups. This is also supported by findings from previous literature.

- These impacts flow through to hard commercial benefits. Around three-quarters of respondents to our survey rated doctorate holders’ contribution to the commercial performance of their organisation be either ‘high’ or ‘medium’; and 83% of respondents believed that doctorate holders had improved their position against competitors.

- The strongest external impact contributions were: standards and good practice; environmental; policy and regulatory; and health and quality of life. Such impacts help to improve the wider economy and society.
• **Chemicals and life sciences** was the sector with the highest impact rating. This is to be expected given that R&D is the essence of this sector, demonstrated by its share of total UK R&D expenditure.

### 5.2 Overall conclusions

This report has set out to determine the return on the investment by EPSRC and others in its doctoral programmes, particularly in non-academic organisations, in order to understand better the economic and social impacts that doctorate holders have. Although previous literature had considered why organisations recruited doctorate holders, there has been little previous research on the impacts that they have on their organisations as well as their wider impacts, for example on the economy, the environment and society.

In setting out the overall conclusions, we relate these to the two fundamental questions of the research.

- What do employers gain from doctorate holders and how does this differ from the value gained from holders of other qualifications?
- In what ways do doctorate holders contribute to the competitiveness of the employer, both directly (e.g. through contribution to innovation via knowledge transfer, impact on absorptive capacity) and indirectly (e.g. through their influence on others around them)?

#### 5.2.1 What employers gain

The Leitch Review\(^\text{78}\) recognised that postgraduate skills levels are one of the most influential factors for improving productivity through their impact on the key drivers of innovation, entrepreneurship, management, leadership and research and development. The higher skill levels are also important for promoting greater collaboration between industry and academia. *DTZ’s survey of employers supports the Leitch Review’s conclusions.*

The UK is recognised to have one of the best science bases among the advanced countries. Access to expertise and qualified staff are key determining factors for location of R&D by global firms\(^\text{79}\). Education is therefore essential in order to produce the scientists, technologists and engineers that provide a healthy base across subject disciplines, and the essential characteristics to attract investment and sustain R&D excellence.

The Roberts Review had suggested that PhD graduates were not well prepared for employment in either academia or business because a PhD degree does not fully prepare students for careers and there is a lack of training in interpersonal and communication skills, management, and commercial awareness to benefit a modern business or teaching environment. This issue did not emerge strongly in our research, possibly because our focus was on the research intensive industries.

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\(^{78}\) *Leitch Review of Skills, Prosperity for all in the global economy*, 2006.

\(^{79}\) *Global R&D: Where to place the bets?*, Arthur D. Little, 2006
Organisations certainly prefer those they employ to have relevant previous commercial experience and evidence was found of organisations seeking to do this with students on doctoral programmes. For example, *there is now more collaborative working between industry and academia as well as innovations such as doctoral training centres, which are providing some of the communication and commercial training that many employers require.* The emergence of industrially relevant doctoral programmes involving research placements with employers, such as EngD programmes and case studentships, are also helping in this regard.

“The requirement for PhD graduates hinges on ‘Open Innovation’ – identifying and developing ideas from outside the company. This requires an ability to communicate effectively with the research community. Dialogue and ‘knowledge exchange’ are the key.”

Nevertheless, the literature does demonstrate that there are negative perceptions of PhD graduates in the labour market, especially where employers are not aware of the attributes or contributions of doctorate holders. Such attitudes towards PhD graduates clearly represent significant barriers to employment and the best use of such graduates’ skills. However, they do not appear to be prevalent in the research intensive organisations.

There were some mixed messages on the level of demand for doctorate holders, particularly within the latter stages of our qualitative research programme. A number of large companies are reducing their recruitment of doctorate holders significantly, while others, including a number of innovative SMEs, are increasing their demand. SMEs are recruiting PhDs not just for their subject skills, but also because of their ability to move and develop quickly within the organisation. This is also supported from previous research. However, there have been notable structural changes in a number of large R&D employers in the UK, and they are moving away from conventional recruitment of doctorates into their functions towards outsourcing, collaborative working and rationalisation in a continuing search for cost effectiveness of delivery.

Despite companies changing their modes of recruitment, the overarching finding from research intensive businesses is that a good quality supply of high calibre doctoral qualified staff from within the UK is of paramount importance due to:

- the contribution that doctorate holders play in supporting critical research functions across research intensive sectors such as automobiles, pharmaceuticals, aerospace and IT;
- the important external benefits generated from investment in doctoral education, such as government policy, industry standards, health and environmental benefits; and
- the impact that doctoral education has on the academic standing of the UK’s universities and research institutes, and the impact this has on attracting and retaining a thriving R&D industry.

80 Survey of employer attitudes to postgraduate researchers, Prospects, August 2006
81 Survey of employer attitudes to postgraduate researchers, Prospects, August 2006
5.2.2 Contributions of doctorate holders

Employers believed that doctorate holders made a number of direct impacts to their organisations, particularly in the areas of: technical expertise; innovative/creative thinking; and problem solving and trouble-shooting capabilities.

A number of indirect impacts were also identified, particularly in the areas of: absorptive capacity of organisation; access to knowledge networks outside company; flows of knowledge within the company; promotion of a learning culture; and skills and productivity of other employees. PhD holders help firms to adapt to change, for example in markets, technology and science, by improving their internal capabilities through such indirect impacts. Companies that employ PhD holders also benefit from ‘technology exchange’, enabling organisations to take advantage of technology transfer and exchange in a collaborative fashion. This is becoming increasingly important in research intensive industries, and the ability of PhD holders to network with academic bodies and others in the market is highly prized by organisations that are developing this form of collaborative working.

Not surprisingly, direct impact is rated as having a higher impact than indirect impact. The competencies of doctorate holders valued most highly by research intensive employers relate to their ‘generic research’ skills, which are critical for the effective execution of a research function. Employers credit the direct impact of their doctorate holders to this same generic research skills set.

However, the indirect impact findings are also very strong and they relate to the contribution of doctorate holders in improving the absorptive capacity of their organisations for which they work. This is attributable to their communication, team working and networking internally and externally with academic and industrial partners.

Our survey results demonstrate that research intensive employers tend to rate research skills, problem solving, data analysis and communication competencies higher than broader based management and leadership skills. These findings are consistent with a number of other studies, such as CIHE\(^{82}\) and Jagger and Connor\(^{83}\).

“PhD holders will be recruited by and benefit cutting edge research organisations.”

However, it was also clear that employers saw doctorate holders as improving their commercial performance, through making a direct positive contribution to profit and turnover, and improving their competitive advantage in the marketplace. In fact, 40% of our sample classified the latter impact as ‘high’. Employers therefore see a clear knock-on consequence of doctorate holders not just improving research functions and systems and improving skill sets, but also in improving the organisation’s overall results and market positioning – its key performance measures.

“The PhD holders are driving the organisation in that they are carrying out innovative research that makes a difference to how things are done.”

\(^{82}\) Absorbing Research: the Role of University Research in Business and Market Innovation, CIHE, May 2010

“The organisation is constantly changing: new systems are being developed and processes evolving. In addition, the market has a lot of competition from other players. It is therefore essential that the company has the brightest people who can innovate and bring new ideas. Without these new ideas, the business would fall behind some of the other big players.”

Impacts were high across all research intensive sectors examined, and for different sizes of organisation, but were particularly high in the chemicals and life sciences sector.

Organisations also believed that there were considerable impacts of doctorate holders outside the organisations in which they work (external impacts). This was particularly in the areas of providing new knowledge or improved ways of doing things, which are used by other companies in the same sector or area of business; and new or enhanced products or processes, which enable successful developments in other business areas (e.g. in IT hardware/software).

The most important external impacts were seen in the areas of standards and good practice; environmental; policy and regulatory; and health and quality of life. Societal and cultural impacts were seen as less important, but were still judged to be ‘high’ or ‘medium’ by one-third to one-half of the survey sample.

The level of doctorate holders’ impacts develops very strongly during their first two years with the organisation.

“A key focus of this research has been to try and improve our understanding of not just the nature and significance of impact from doctorate holders, but also the way in which the impact is created. We have referred to this as the ‘transmission mechanism’. This is a complex area and the literature review has confirmed that there is no seminal work that sheds much light on this subject. However, based on our literature review and the findings of our primary research, which has focused on ‘research intensive’ organisations, we have developed an impact and transmission mechanism framework (see Figure 5.1).

The overall framework is based on a straightforward logic model, which has evolved from the original model, illustrated in Figure 1.1, which links the inputs at one end of the spectrum to final impacts at the other end. We have also provided a number of examples, based on our research work, of what these inputs, outputs and impacts are. Furthermore, we have made the important distinction between impacts at the employer level versus the wider impacts on third parties, be this government, commercial partners or other research intensive organisations.

One of the objectives of the in-depth interviews was to ‘stress test’ this model to determine whether it could be applied in practice and therefore provide concrete examples of how the transmission mechanism can work in practice. It was reassuring to discover that the model was directly applicable to most of the consultees, although, as one would expect, the nature and level of impact does vary quite significantly from organisation to organisation.
Figure 5.1 Impact framework and transmission mechanism for ‘research intensive’ employers

- **Pre-employment**
  - PhD training
  - Post-doc fellowship & internships

- **Post-employment**
  - On-the-job training
  - Specialised technical & generic competency training

**Employer Impact**

**Direct (the employer)**
- Technical /research skills
- Innovative thinking
- Problem solving
- Capacity building: individual, team & organisational levels

**Research Impact**
- Innovation & IP
- New & enhanced products/processes
- Transformational impact

**Indirect (partners)**
- Universities
- Institutes
- Business Partners
- Suppliers
- Customers
- Government

**Overview of PhD Research Roles**
- Scientific /laboratory research
- IT/software development
- Advanced process engineering

**Open Innovation & Knowledge Exchange**

**Outputs – Intermediate**

- PhD training
- Post-doc fellowship & internships

**Outputs – Final**

- On-the-job training
- Specialised technical & generic competency training

**Overall impact**

- Economic contribution – GDP/person; employment; spillovers
- Environmental contribution – CO₂ emissions; recycling; renewables
- Societal contribution – supporting disadvantaged areas/groups; health benefits; social inclusion and regeneration

**Source:** DTZ
5.2.4 Transmission Mechanism – Example from the Automotive Sector

The following illustration from the automotive sector gives a bespoke example of how doctorate holders deliver impact internally for their organisation in terms of innovation, product development and commercial performance; and externally for the benefit of the automotive industry, the health and safety of passengers and pedestrians, the environment, and wider government policies and industry standards. There is also a clear ‘feedback loop’ of the company’s activities and outputs being partly determined by the needs of their customers and the actual impacts achieved (see Figure 5.2).

Operating at the premium end of the automotive industry, the performance of this company is heavily dependent on the contribution of its ‘Research and Advanced Engineering Centre’, which leads on the development of new technologies and prototypes that are then rolled out to the production teams for development into viable commercial applications for manufacture. The ratio of PhD to total staff complement is high at 15% (30 out of 200) and this number is going to increase in the future.

**Internal Impact – Transmission Channels**

The most important impact is the development of leading edge technologies and systems which can be applied to the company's product line. Hence, the relationship between the Research and Advanced Engineering Centre and the Product Development teams is critical in embedding new technologies. Product development and enhancement drives sales and commercial performance for their business, as highlighted from our qualitative research.

**Examples of Innovation Impact**

“There are numerous examples of major technological breakthroughs, where the teams have been led and supported by doctorate holders. This includes the following:

- Dual view screens
- Advanced active safety systems
- Advanced hybrid models in development

This ensures that our vehicles are competitive in the market place in terms of new features and innovation and so are perceived as up-to-date and appealing to the customer. This translates into sales, income and profit.”

**External Impact – Transmission Channels**

There are numerous transmission channels through which the Research and Advanced Engineering Centre confers wider benefits:

- **Knowledge Exchange** – this is affected through the company's investment in its academic linkages with centres of research excellence in the UK. This encompasses joint research projects, contract research, PhD sponsorship and CASE Studentships.

- **Supply Chain Linkages** – through the joint development of new systems and technologies with 1st and 2nd tier suppliers. This is a ‘win-win’ in that the Research and Advanced Engineering Centre can draw upon leading edge innovation in its supply base; and the suppliers benefit from the market drive and leadership from the automotive Original Equipment Manufacturer (OEM) and the placement opportunities it provides for the roll-out of new technologies and sub-assembly systems.
Figure 5.2 Example of Impact Transmission Mechanism – the UK Automotive Sector

Internal Impact of PhDs

Research & Advanced Engineering Centre
- Innovation leadership
- Capacity building
- Absorptive Capacity
200 staff (incl. 30 PhDs)

Product Development
- Receiving the innovations and applying to automotive manufacturing process
- Supply chain linkages
4,000 staff (incl. 40 – 50 PhDs)

Manufacturing & Distribution
- Assembly line production
- Distribution/sales function

External Impact of PhDs

Academic Linkages
- Research know-how
- PhD sponsorship/CASE studentships
- Recruitment

Supply Chain
- Collaborative research with suppliers
- Capacity building of suppliers
- Sustainability and performance of UK supplier base

Other Stakeholders
- Government – policy, etc.
- Research Councils – focus & funding
- Industry – SMMT, etc

Commercial Impact
- Turnover and profit
- Sustainability – long term customers
- Organisational reputation & image

Wider Impacts
- Health – passenger and pedestrian safety
- Environment – CO₂ emissions, transport efficiencies, etc.

Source: DTZ
• **Other Stakeholders** – finally, the Research and Advanced Engineering Centre helps inform policy and industry standards developed by government and industry representative bodies such as the Society of Motor Manufacturers and Traders (SMMT). It also works collaboratively with the Research Councils and helps inform research funding policy.

**Examples of External Impacts**

“A number of our PhDs have been appointed as ‘Technical Specialists’, where their leading edge knowledge means that they provide a wider ambassadorial function on behalf of our company. They talk at conferences and become known in the industry for their specialism. This helps build our company’s reputation and image with our key stakeholders.

They also build a portfolio of university based research for their area of the business:
- PhD – pedestrian safety specialist
- PhD – Active safety specialist
- PhD – hybrid car specialist
- PhD – Low carbon technology specialist

This helps raise our profile in the academic community and assists us in recruiting the top researchers relevant to our business.

Our specialists also liaise with Government, the Research Councils and the Society of Motor Manufacturers and Traders (SMMT) on strategy, policy, industry standards, environmental and societal issues. For example:
- Process improvements, measurement standards and design standards
- Development of policy and best practice.”

**Final Impact**

The consequence of this highly effective ‘transmission mechanism’ is that the automotive OEM achieves technological first mover advantage in the market place – which is a ‘must-have’ for success in what is a highly competitive global industry. Secondly, it confers wide-ranging external benefits which contribute to the improved performance of the UK economy; provide demonstrable health and safety benefits for passengers and pedestrians; and contributes significantly to the environmental agenda through a reduction in CO2 emissions.

**Examples of Wider Impacts**

“From the innovation led by doctorate holders described above, our company is heavily involved in supporting the government’s policy goals relating to the environment, health and safety:

- **Environmental Impacts** – central to our research is the development of low carbon technologies to reduce the impact of our vehicles. We are also heavily involved in researching journey planning and multi-modal choice – where car transport fits most effectively with train/plane.
- **Health and Safety** – we are concerned not just with the safety of vehicle drivers and passengers, but also pedestrians. We need to understand society and the individual and the changes in both. For example, we need to consider the blind person crossing the road who cannot see the car coming.”
APPENDICES

- Appendix A – Bibliography
- Appendix B – List of consultees
- Appendix C – Topic guide
- Appendix D – Qualitative research - demand side feedback (employers)
- Appendix E – Qualitative research - supply side feedback (representative and umbrella organisations)
- Appendix F – Quantitative research - questionnaire
- Appendix G – Quantitative research - survey results
Appendix A – Bibliography for literature review

<table>
<thead>
<tr>
<th>Source of Literature</th>
<th>Focus of Literature</th>
<th>Inclusion criteria</th>
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</thead>
<tbody>
<tr>
<td>Increasing the economic impact of Research Councils, Advice to the Director General of Science and Innovation, DTI from the Research Council Economic Impact Group, 2006.</td>
<td>Sets out a series of recommendations on how the Research Councils can increase economic impact.</td>
<td>√</td>
</tr>
<tr>
<td>Leitch Review of Skills, Prosperity for all in the global economy, world class skills, 2006.</td>
<td>The UK’s long-term skills needs and current base, the importance of education, and how skills impact on productivity.</td>
<td></td>
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<tr>
<td>Doctoral Career Pathways, Skills and Training Options analysis for the collection of information</td>
<td>Information on how to assess career path information, highlighting lack of information on impact.</td>
<td>√</td>
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</table>

Inclusion criteria:
- Impact (✓)
- Employer outcomes (✓)
- Destination (✓)
- Physical sciences and engineering PhDs (✓)
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<th>Source of Literature</th>
<th>Focus of Literature</th>
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<td>about the early careers of UK Doctoral Graduates, University of Warwick, 2008.</td>
<td>First destinations of doctoral graduates by subject and career profiles of doctoral graduates.</td>
<td></td>
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<tr>
<td>Employers’ views of researchers skills - A comprehensive review of the existing literature into employers’ views of the skills of early career researchers, The Rugby Team, September 2007</td>
<td>Summary of information and conclusions from studies which relate to recommendations from the Roberts’ review.</td>
<td>✓</td>
</tr>
<tr>
<td>STEM Review – the Science, Technology, Engineering, Maths Supply Chain, CIHE, March 2007</td>
<td>The report reviews what the various key players are doing and the impact of implementation of Roberts’ recommendations.</td>
<td>✓      ✓      ✓</td>
</tr>
<tr>
<td>Recruiting PhDs – What works? The UK Grad Programme, March 2007</td>
<td>This study aims to highlight what works for employers and university career services in supporting, targeting and recruiting PhD researchers.</td>
<td>✓      ✓</td>
</tr>
<tr>
<td>Promoting the UK doctorate: opportunities and challenges, Universities UK</td>
<td>This report brings together issues arising from policy developments and their impact on doctoral study, the range and diversity of doctoral programmes, the nature of the doctoral researcher cohort in the UK and the development of the third cycle in the Bologna process.</td>
<td>✓</td>
</tr>
<tr>
<td>Survey of employer attitudes to postgraduate researchers, Prospects, August 2006</td>
<td>The focus of the research was to address two main questions: 1) Why do employers recruit PhDs and contract researchers? and, 2) Why might certain employers not recruit from these cohorts?</td>
<td>✓      ✓</td>
</tr>
<tr>
<td>Employers’ perceptions of recruiting research staff and students, Prospect</td>
<td>Focuses particularly on external employers’ perceptions of recruiting people with a university research background.</td>
<td>✓      ✓</td>
</tr>
<tr>
<td>Source of Literature</td>
<td>Focus of Literature</td>
<td>Inclusion criteria</td>
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<tr>
<td>Employers’ Views of Postgraduate Physicists, Institute for Employment Studies to the EPSRC, February 2001</td>
<td>Examine the views of those who employ postgraduate physicists as to both the quantity and quality of the current provision.</td>
<td>✓</td>
</tr>
<tr>
<td>The Role of PhDs in the Smart Economy, Forfas/Advisory Science Council, December 2009</td>
<td>The Advisory Science Council appointed a task force to examine the enterprise demand for PhD researchers, the roles they fulfil in enterprise and to identify the barriers that reduce the “pull” of graduates to enterprise.</td>
<td>✓</td>
</tr>
<tr>
<td>Global R&amp;D: Where to place the bets?, Arthur D. Little, 2006</td>
<td>In this article the authors describe how global firms can set up R&amp;D networks that provide maximum benefit in their endless search for innovation.</td>
<td>✓</td>
</tr>
<tr>
<td>A study on rates of return to investment in Level 3 and higher qualifications, Warwick Institute for Employment Research, November 2005</td>
<td>This report provides a detailed examination of the labour market returns to qualifications in the UK.</td>
<td>✓</td>
</tr>
<tr>
<td>Skills, Knowledge and Organisational Performance (SKOPE), University of Oxford</td>
<td>Literature review from the ESRC research centre</td>
<td>✓</td>
</tr>
<tr>
<td>Source of Literature</td>
<td>Focus of Literature</td>
<td>Inclusion criteria</td>
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<tr>
<td>Manathunga, Catherine, Pitt, Rachael and Critchley, Christa (2009) <em>Graduate attribute development and employment outcomes: tracking PhD graduates</em>, Assessment &amp; Evaluation in Higher Education, 34: 1, 91 — 103</td>
<td>Pilot study to examine the impact of research training provided by the Australian Cooperative Research Centres (CRC) programme</td>
<td>✓</td>
</tr>
<tr>
<td><em>Talent Fishing – What Businesses Want from Postgraduates</em>, CHIE report for BIS, 2010</td>
<td>The research was undertaken by CIHE and surveyed over 40 employers. The research respondents were drawn from both industrial and business services sectors, and included many of the UK’s major businesses, multinational organisations as well as a number of smaller organisations.</td>
<td>✓</td>
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Appendix B – List of Consultees

Client representatives
Maggie Wilson, EPSRC
Kate Reading, RCUK
Rebecca Stiliaros, EPSRC
Rosa Fernandez, BIS
Sue Smart, EPSRC

Employer organisations
Accelrys Limited
Agilent Technologies
AgustaWestland
Airbus
Aircraft Research Association Limited
Alphasense Ltd
Alstom Grid Power Electronic Systems Limited (formerly AREVA T&D Power Electronic Systems)
ARM Ltd
AstraZeneca
Astrium Ltd
Atomic Weapons Establishment
Avid Vehicles Ltd
BAE Systems
Biomet UK Ltd
Biomolecular Discovery
Bombardier Aerospace
Bristol-Myers Squibb Pharmaceuticals Ltd.
Cambridge Display Technology Ltd
Cellcentric Ltd
Chas A Blatchford & Sons Ltd
Compound Semiconductor Technologies Global Ltd
Controlled Therapeutics (Scotland) Ltd
Convatex
Corus
Croda
Delphi Diesel Systems Ltd
Domainex Limited
Doosan Babcock Energy
Dynex Semiconductor Ltd
Eli Lilly & Company Ltd
Ford
Goodrich Corporation, UK
GSK plc
G-Volution (formerly Zeonardo Limited)
Haemair Ltd
Health and Safety Executive
HILTech Developments Limited
Honeywell
HP
Innospec
Insight Health Ltd
IXICO Ltd
Jaguar Cars Ltd
Jaguar Land Rover
McLaren Automotive Ltd
Medimmune
Merck Sharp & Dohme Ltd
Messier Dowty
Michelson Diagnostic Ltd.
Microsoft
Molnlycke Health Care
Morgan Est
National Grid
National Physical Laboratory
NATS Ltd
Nemaura Pharma Limited
Neu-Rehab
Nokia Research Centre
Novartis
Oxford Quantum Computing Ltd
Oxsensit Ltd
Pall Life Sciences
PerkinElmer
Perkins Engines Co Ltd
Pfizer
Philips Healthcare (a business of Philips Electronics UK Limited)
Prolysis Ltd
QinetiQ Ltd
Reaxa
RecipharmCobra Biologics Ltd.
Reckitt Benckiser (formerly Reckitt and Colman Products)
Revolymer Ltd
Ricardo
Rolls Royce
Sanofi Aventis
Sauflon Pharmaceuticals Ltd
Scottish & Southern Energy
Scottish Water
Selex Sensors and Airborne Systems
Siemens
Sitekit Solutions Ltd
Sonar Link Ltd
STMicroelectronics
Sumed International (UK) Ltd
TATA Motors
Thales Research and Technology
Thermacore Europe Ltd.
TRW Conekt
TWI
Unilever
Vascutek Terumo Ltd
Vodafone
Wellahead Engineering Ltd.

**Umbrella bodies**
Association of British Healthcare Industries
Association of British Pharmaceutical Industry
Chartered Institution of Water & Environmental Management
Energy & Utility Skills
Financial Services Knowledge Transfer Network (FSKTN)
Institute for Mechanical Engineers
Institution of Engineering & Technology
Research Councils UK
Royal Academy of Engineering
Royal Society of Chemistry
Royal Society of Medicine
Science and Technology Facilities Council
SEMTA
Skills for Health
The Energy Institute
UK Commission for Employment & Skills

**Phase 1 workshop – organisations represented**
AGCAS - Association of Graduate Careers Advisory Services
AHRC - Arts & Humanities Research Council
BIS - Department for Business Innovation & Skills
CBI – Inter-Company Academic Relations Group
CIHE - Council for Industry and Higher Education
EPSRC - Engineering & Physical Sciences Research Council
ESRC - Economic & Social Research Council
HEFCE - Higher Education Funding Council for England
HESA - Higher Education Statistics Agency
IER - Institute of Employment Research) - Vitae/Impact and Evaluation Group
IES - Institute of Employment Studies
NERC – Natural Environment Research Council
Newcastle University
RCUK – Research Councils UK
STFC – Science & Technology Facilities Council
The Wellcome Trust
Appendix C – Topic guide for Phase 1

1. Introduction

*Script for Interviewer:* The EPSRC and RCUK have appointed DTZ to conduct a study to measure the economic impact of doctoral level training. The main focus will be on PhDs in engineering and the physical sciences and employers that employ postgraduates in these disciplines. The study will address three key questions:

- What do employers gain from doctorate holders and how does this differ from the value gained from holders of other qualifications, specifically first degrees?
- In what ways do doctorate holders contribute to the competitiveness of the employer, both directly in terms of innovation and productivity benefits; and indirectly through supply chain linkages, customer and partner relationships?
- In what ways do doctorate holders contribute wider economic environmental and societal benefits, for example, through the application of their knowledge and skills to bring about improvements in areas such as healthcare, energy provision, security, etc?

This first phase of this study involves consultation with organisations that are likely to have strong views on this subject due to their remit (interviewer to select appropriate consultee category from list below):

- Funders of doctoral level training – specifically the Research Councils
- Industry bodies and employers’ associations which are focused on engineering and physical sciences and where the employment of PhD staff is commonplace
- Professional and scientific bodies which are relevant to the engineering and physical sciences sectors.

The objective is to obtain your views on this subject, access any relevant reports and data you may have and further contacts which could be relevant to our work. The interview is based on a structured questionnaire checklist and we expect it to last up to a maximum of 45 minutes. Please specify if any of the information or views expressed are of a confidential nature and DTZ will respect this.

*Briefing Notes for Interviewer:*
At the conclusion of the Introduction, we need to check that the consultee organisation considers itself to be relevant to this study and is willing to participate in the interview. The questionnaire sections 2 – 5 will need to be drawn upon flexibly by the interviewer reflecting the profile of the consultee organisation and its remit/interests.

2. Profile of Organisation

a. Remit of organisation – what are its key objectives and activities?

b. PhD focus – does the organisation have any specific focus on supporting the uptake of PhDs? (Note: external focus – not its own recruitment of PhD graduates which is discussed below)? If yes specify:

   i. Funding support (e.g. Research Councils) – quantify if possible e.g. per annum/no. of places, etc.

   ii. Awareness raising/non-financial measures
3. **PhD Uptake by Organisation**

   Note: The focus of this section is on the organisation’s own use of PhD graduates.
   a. **FILTER** - Does your organisation have any PhD graduates or have had in the past?
   b. Do you actively seek to recruit PhD graduates? Why is this?
   c. What are the specific strengths of the PhD graduates you have employed (compared to holders of other qualifications, specifically first degrees?)
   d. How have they added value to your organisation? (need to probe, taking account of the nature of the jobs undertaken, job size and contribution within this context)
   e. What additional training/investment do you provide to PhD graduates when they enter your organisation? Does this differ from what is provided to other graduates?
   f. Could your organisation make better use of PhD graduates? If yes, how?
   g. What improvements could be made to the PhD programme to ensure a higher standard of graduate? How could this be achieved?
   h. What would be the consequences if your organisation could no longer recruit PhD graduates? a) On your organisation? b) On the wider economy, environment and society?

4. **PhD Uptake by Sector /Industry**

   Note: The focus of this section is on the organisations views of the use of PhDs within the sector(s) it has oversight of/responsibility for.
   a. Describe the ‘constituency’ of your organisation in terms of sectoral/technology focus (building on Section 2 information)
   b. How important is the recruitment of PhDs to this sector? Explain
   c. Does recruitment vary by firm type (size, remit, technology focus) and sub-sector? If so, why do you think this is?
   d. What demand and supply issues, if any, are there in these sub-sectors in terms of employment of PhD graduates?
   e. What types of impacts do the PhD graduates create in organisations? Prompts – on productivity, turnover, process improvement. training of others, performance of others, wider societal impacts.
   f. How are these impacts achieved? Prompts – innovation, knowledge transfer, research methods, specialist knowledge/skills, team working, learning culture.
   g. To what extent are these impacts unique – compared to what can be delivered from those with other qualifications, specifically those with first degrees?
   h. What would be the consequences if your sector(s) could no longer recruit PhD graduates? i) On the organisations concerned? ii) On the wider economy, environment and society?
5. **Contribution to Study**

   Note: The focus of this section is to identify how the consultee organisation could assist with the further progress of this study.

   a. **Literature & data** – does your organisation have, or know of, any reports or data that could assist with this overarching research theme of the impact of PhDs?

   b. **Impact work** – relating to the above, has your organisation attempted to measure the impact of PhDs? If yes, please give details?

   c. **Contacts** – are there any consultees that you would recommend we speak to as part of this study (note: probe for ‘engaged’ and representative companies which would be suitable for the pilot survey)?

   d. **Phase 2 survey** – Would you be able to provide access to a ‘membership’ list of firms that would be suitable for consultation in Phase 2 of this work? If yes, provide parameters and review confidentiality issues.

6. **Summary**

   a. Summary of key issues raised (recap by interviewer)

   b. Any other observations or questions from interviewee (probe for any gaps or additional information)

   c. Thank and close
Appendix D – Employer feedback – qualitative research findings

Box D.1 Examples of formalised approaches to the recruitment of PhD qualified staff

Employer A. Postdoctoral Fellowship Programme – “We offer a two-year training programme offered to PhD and M.D students that allows them to gain and expand scientific expertise while working under the direct supervision of a senior scientist. During the two-year training period, we provide each fellow with the opportunity to participate and complete research project(s) that encompass exploratory research, new technologies and/or novel methods to advance research and development related to the strategic interests of the Research Laboratories worthy of publication in peer-reviewed scientific journals. Each fellow is also provided with a mentor.

However, the Postdoctoral Fellowship Programme is not intended as a primary recruiting tool to fill senior scientist positions. Instead, it provides a Fellow with valuable training so that the individual can accept opportunities in industry or academia upon completion of the Programme.”

Employer B. PhD Scholarship Programme – “This programme supports PhD students in scientific disciplines related to our focus. We usually only select one application per university department or per laboratory of a national research institution.

The scheme provides an annual bursary for up to three years. Scholars are invited to a leading UK university for an annual Summer School that includes a series of talks of academic interest and which provides the scholars with the opportunity to present their work to the employer’s researchers and a number of academics. Some of the scholars may also be offered, at the sole discretion of the employer, an internship in one of their laboratories. Internships involve working on a project alongside and as part of one of their research teams. Scholars are paid during their internship, in addition to their scholarship bursary.”

Employer C. Internship – “These are offered for undergraduates and advanced degree students (e.g. MBAs, Masters and PhDs). Internships last about 12 weeks and include salary; in some cases relocation benefits are provided. Once interns complete a successful internship, we may extend an offer for full-time employment based on business need and availability. Internships are offered in fields such as Operations, Engineering & Technology, Finance, or Marketing & Business Management.

The internship programme is open to engineering and technology PhD students from target universities around the globe. Through a scholarship programme, students have the opportunity to receive a paid internship at an employer facility, and scholarship money to apply toward their final school year. However, this is only open to candidates in China, Czech Republic, India, Malaysia, Mexico and USA – not the UK.”

Source: DTZ

84 The employers in this and the other box diagrams are anonymised in this Appendix. Note that there is no read through to other boxes in this appendix, .e.g. ‘Employer A’ in Box E.1 is not the same as ‘Employer A’ in Box E.2.
Box D.2 Employer feedback on competencies

**Employer A** – “The level of knowledge that is required for the job is very high so employees are PhD holders; they will know a lot about particular aspects of chemistry relevant to our business. The staff are essentially scientists/chemists and they need to have a high level of knowledge of chemistry to do the job. It would not be practical to employ graduates as it would take too long to just train them to the standard required. The roles are extremely specialist, e.g. medicinal chemistry, biological chemistry, which is at a much higher level than is being taught at university. Other skills brought to the job include:

- Methodologies of research: not just the knowledge of the science itself but actually how to apply the findings of research. Technical skills. Strong analytical skills and expertise
- Innovation: The PhD holders are driving the organisation in that they are carrying out innovative research that makes a difference to how things are done. There may be less people that have PhDs but the impact they have is large.”

**Employer B** – “It also takes a certain type of person to study a PhD – is it the qualities that a PhD student learns through studying? Or are these qualities already innate in a PhD student? For example an inquiring mind?”

**Employer C** – “PhD holders are also more confident, they show leadership skills as a result of working independently, whereas other graduates need to be shown what to do. The experience of the commercial world is not there with PhD holders, but there is a real and valuable knowledge of how to exploit the literature and knowledge of research methods that could not be replaced by graduates. Graduates require more training and support to get them up to the same sort of standard.”

**Employer D** – “One challenge with PhD holders is that they strive for perfection. For example, it can be difficult for them to deliver a project to a set deadline. In academia, PhD students can spend a long time looking for clear answers to a problem. However, in industry, staff have limited time and must therefore make decisions based on limited knowledge; this is something that PhD holders do not always like. They have been taught to strive for truth and knowledge, but this cannot always be done in the workplace.”

**Employer E** – “PhD graduates add value by being bright and fast learners.”

**Employer F** – “PhD qualified staff tend to achieve faster progression up the career ladder, for example, they become Team Leaders quicker than those going through the Graduate Scheme. The only downside is with overseas PhD qualified staff – they don’t tend to stay and instead go back to their home country with their accumulated experience. This is a net loss to UK plc.”

**Employer G** – “The areas where a graduate starting work in our business would learn more than a postgraduate doing a PhD include:

- teamworking;
- managing more than one project at a time (handling a faster pace of work); and
- management skills and understanding what happens in reality rather than in theory.”

Source: DTZ
The umbrella organisations reinforced the above findings. Again, there tended to be polar extremes between those organisations supportive of PhDs and those for whom the investment was seen as not relevant to their sector.

**Box D.3. Umbrella organisation feedback on competencies**

**Organisation A** – “PhD holders bring with them not just the technical knowledge and skills that are needed but also bring with them the ability to ‘think outside the box’.

The work is often ground breaking and revolutionary and requires people who are free thinking. PhD holders who go into industry are people who want to change the world and make a difference. These types of skills are not something that can be learnt on the job.”

**Organisation B** – “In terms of the engineering sector, the most employable people will be those who are numerate and who have a basic understanding of engineering. If someone has studied for a PhD, they will have very detailed, specialist knowledge in one project area and this is not really what many employers are looking for.

They are also often not used to the commercial pressure – deadlines and having to work in order to make money, it is not just about intellectual pursuit, and this can sometimes be difficult for PhD holders to understand. In industry, employees need to see how the research they work on impacts the rest of the business: they need to be able to see the bigger picture. Often, PhD holders do not have this mentality as they have spent too long working on their own on very narrow fields. Far too many PhD holders go into academia. If you look at who the managing directors are in engineering companies, there will be very few who hold PhDs.”

**Organisation C** – “PhD holders are people who ‘think outside the box’ and who can gather information. They are horizon scanners - some employers like this, some do not. PhD holders will be recruited by and benefit cutting edge research organisations.”

**Organisation D** – “PhD holders bring scientific research skills that are intrinsic to how some organisations operate. They bring about change and advancement.”

**Organisation E** – “The requirement for PhD graduates hinges on ‘Open Innovation’ – identifying and developing ideas from outside the company. This requires an ability to communicate effectively with the research community. Dialogue and ‘knowledge exchange’ are the key, rather than the old model of massive ring-fenced R&D teams controlled by major corporates.

The benefit of PhD trained staff is not the technical knowledge per se, but rather the training it gives them.”

**Organisation F** – “PhDs tend to have better critical thinking skills, question approaches to problems (instead of merely accepting a standard approach), work through a problem before commenting and have a willingness to challenge.”

Source: DTZ
# Box D.4 Employer feedback on PhD graduate career progression

**Employer A** – “PhDs open doors for people. People start at a higher level and can progress in their career quickly. I would never have got to his position without having first had a PhD.”

**Employer B** – “PhDs start at a higher level than graduates and need less on the job training, so can move up the ladder quicker.”

**Employer C** – “PhDs can aspire to be a Fellow in our organisation, with a focus on project and people management, or a Chief Engineer on a leading specialism.”

**Employer D** – “PhD qualified staff tend to achieve faster progression up the career ladder, e.g. they become Team Leaders quicker than those going through the Graduate Scheme.”

**Employer E** – “We do have a salary increment for PhD-level recruits, but, thereafter, career progress is up to the individual. Although we do not impose PhD requirements for progress beyond any particular level, PhD recruits do indeed tend to progress further and more quickly.”

**Employer F** – “PhD holders have a ‘passport’ to career progression, particularly if they can combine their technical skills with good communication skills. Normally, PhD holders will be placed at a higher level than graduates and will go straight into team leader positions. They then tend to progress quickly. It is expected that PhD employees will be at a higher level – they are used to more responsibility and freedom to work.”

**Employer G** – “It is the norm for PhD graduates to fill the Team Leader roles in research – it is the route to career progression in the company.”

Source: DTZ
Box D.5 Employer feedback on training provision

**Employer A** – “No technical training is given. Staff are expected to know how to work in a lab and conduct scientific research. However, PhD holders do lack the skills needed to deal with customers; this is something that the staff need to work on when they join. Business/commercial sector knowledge does not come naturally to PhD holders, but it is something that they can learn. The firm provides inter-personal training, which greatly helps with this.”

**Employer B** – “On-the-job training is provided: PhD holders are expected to be able to go into a job and require little technical training.”

**Employer C** – “PhDs are expected to be able to work independently and need much less training than say graduates.”

**Employer D** – “No formal training, but will provide on-the-job training in communications, interpersonal skills etc.”

**Employer E** – “Recent [under]graduates spend 18 months going round the company on starting, finding out about the different departments and activities. Direct entrants, like PhDs, need a shortened version of this on employment, but it depends on the skill line.”

**Employer F** – “We do not provide a generic training programme for PhD graduates when they join the company. Their training support is no different from what would be provided for other direct entrants. If necessary, a training programme is developed to meets the needs of the individual and the job they are fulfilling.”

**Employer G** – “We have a suite of training modules, from science to leadership. However, these are not bespoke for PhDs and there is no specific programme for them. Instead, training will be provided internally at Department level on a bespoke basis to meet their requirements in terms of science, leadership, etc.”

Source: DTZ
Box D.6 Employer feedback on impact of PhDs

**Employer A** – “The PhD holders are driving the organisation in that they are carrying out innovative research that makes a difference to how things are done. There may be less people who have PhDs but the impact they have is large.”

**Employer B** – “The organisation is constantly changing: new systems are being developed and processes evolving. In addition, the market has a lot of competition from other players. It is therefore essential that the company has the brightest people who can innovate and bring new ideas. Without these new ideas, the business would fall behind some of the other big players. Creativity is very important.”

**Employer C** – “The lab is a research centre, so there is a requirement for PhD holders. The centre is currently rated as excellent, as measured in terms of peer review papers. There have also been a number of economic assessments. Without PhD holders, there would not be this standard.”

**Employer D** – “Advantages are seen for doctoral recruiting in terms of innovation (sometimes, fairly directly so) and productivity, including application of their knowledge and skills improvements in areas relevant to the company such as materials, engineering, and electronics. However, quantifying any of this will be difficult.”

**Employer E** - “Where PhD students are employed, this contributes significantly to the £1 billion turnover of the business. Some of our main products are developed by PhD scientists in the company. This is a big business and PhD research has helped to create this. The communication skills of PhD students have also improved. This is important as it raises the profile of the company and consequently leads to more sales.”

**Employer F** – “PhD holders do have an impact in that they bring knowledge and innovation. These are important skills that drive the business forward. Innovation leads to new products, which can lead to increased profits. PhD students have the knowledge and capacity to undertake new research: without this new research, the company would not progress.”

**Employer G** – “The main route to impact for our business is the contribution which a post doctorate makes in the creation of IP as part of an integrated team. He/she will be leading a team of about 5 research scientists.

- 1 in 50 products will become a market leader
- Massive income potential for the business
- But will not know for 10–15 years.

Therefore, wealth creation is the ultimate goal. This will have major benefits internally for our business and externally benefiting human and animal welfare. There are also important spillover benefits cascading to universities, other pharmaceutical companies and the wider supply chain.”

Source: DTZ
Appendix E – Employer and umbrella organisations – supply side feedback

In addition to the research findings relating to the PhD ‘Lifecycle’ model described above, two other themes emerged from the survey work:

- global market context; and
- PhD course structure and content.

Global market context

Drawing together the wider views of the employers and umbrella organisations, it was clear that there was an emerging concern over the PhD supply pipeline in the UK. The key demand and supply factors are illustrated in Table E.7. The key message is that the global market for both skilled staff and corporate investment is highly mobile and there is the potential that the competitive positioning of the UK in the knowledge economy will be undermined through under-investment in PhD level education.

<table>
<thead>
<tr>
<th>Supply side factors (latent)</th>
<th>Demand side factors (current)</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK PhD ‘weakening’:</td>
<td>Global industrial restructuring</td>
</tr>
<tr>
<td>o quantity</td>
<td>Rise of China and SE Asia</td>
</tr>
<tr>
<td>o quality</td>
<td>Increase in demand for highly skilled staff</td>
</tr>
<tr>
<td>Competition from US and Asia</td>
<td>Outsourcing from UK based businesses</td>
</tr>
<tr>
<td>UK government policy and funding</td>
<td>Competition for mobile international investment</td>
</tr>
</tbody>
</table>

UK – At Competitive Disadvantage
- Now - possibly
- Future - probably

Source: DTZ

PhD course structure and content

DTZ’s research in Phase 1 identified a number of models designed to enhance the impact of PhD education. These models build upon the concepts of:

- EngD
- CASE studentships
- Taught Course Centres
- Doctoral Training Centres.

Given the strong demand for more applied and varied education within the PhD education structure, these are profiled below, along with some examples from the Doctoral Training Centres (DTCs). These profiles are based on information obtained from websites that we were directed to in our consultations.
**University Technology Centres**

Rolls Royce sponsors PhD students through a number of University Technology Centres. These are research centres and universities with which Rolls Royce has close relationships. Most of these are in the UK. An example is the UTC at the University of Sheffield. The UTC in Control and Systems Engineering was established in 1993 by Rolls-Royce within the Department of Automatic Control and Systems Engineering at the University.

In this UTC, the University co-ordinates and directs programmes of systems and control research for Rolls-Royce, looking after Rolls-Royce's technical interests in the fields of control and monitoring systems and embedded software. The UTC carries out both short-term and long-term research, with the aim of supporting the company's business aims through improving the product, improving productivity and reducing cost-of-ownership. Applications include:

- gas turbine engines for civil and military fixed and rotary wing aircraft;
- Advanced Short Take-off and Vertical Landing (ASTOVL) aircraft;
- industrial turbo-generator systems; and
- maritime installations.

A number of work programmes are investigating strategic research topics in the field of systems and control law definition, monitoring systems, safety and reliability and systems integration.

**Power Academy**

The IET Power Networks Research Academy (PNRA) has brought together seven leading universities, 15 companies in the power sector, the Institution of Engineering and Technology, and the Engineering Physical Sciences Research Council to develop an engineering scholarship fund that provides outstanding first degree graduates with support and finance for a PhD high-status postgraduate university course.

The Power Academy is a unique partnership between industry and academia, established to address the looming skills shortage in power engineering through a combination of financial support and workplace mentoring for students. 60 scholarships are awarded each year to students at participating universities. A Power Academy scholarship provides:

- a bursary of £2,200 for each year of study;
- contribution towards university tuition fees;
- £220 for books and software;
- mentors from industry partners;
- paid summer work placements; and
- annual high level seminar on important sector issues.

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85 Based on information from: [http://www.sheffield.ac.uk/systemsutc/](http://www.sheffield.ac.uk/systemsutc/)


87 [http://www.theiet.org/about/scholarships-awards/power-academy/](http://www.theiet.org/about/scholarships-awards/power-academy/)
Doctoral Training Centre Model at the School of Chemistry, Bristol University

Bristol has four DTCs, two based in engineering and two in science. The School of Chemistry is involved in both Science Faculty DTCs.

- **Chemical Synthesis**: 'A Holistic Doctoral Training Centre for Chemical Synthesis' is a £7.3M Chemistry-focused programme supported by significant (>£1M) additional industrial funding and training from leading Pharmaceutical, Fine Chemical and Petrochemical companies.

- **Functional Nanomaterials**: 'A Doctoral Training Centre in Functional Nanomaterials' is a joint £6.4M bid between Chemistry and Physics.

These two Centres will each be allocated ten four-year PhD studentships (and associated support costs) per annum over a five-year period, beginning October 2009. PhD students funded by the Centres will therefore have a different experience than students funded by the more traditional routes. First, instead of three or three-and-a-half years, these PhDs will run for four years, with around six months of this time being taught courses (lectures, workshops, etc.), and the remainder being research and associated research training. The taught courses will be specially written for each Centre providing advanced teaching on different aspects of the field (Chemical Synthesis or Functional Nanomaterials). The Bristol Chemical Synthesis DTC will be further supported by bespoke lectures and workshops from leading companies from Pharmaceutical and Fine Chemical Industries. Within Functional Nanomaterials, it is envisaged that some lectures will take place in Chemistry, and some in Physics.

These Centres are designed to provide first class training in both research and the technical/academic aspects of their subject. The DTC PhD studentships will be both prestigious and highly sought-after, and the research topics will be flexible and adventurous. A key feature of the DTC programme is that PhD supervisors and projects are selected immediately; rather the DTC students are able to gain experience and insight into the large array of topics and supervisors available, before making that key decision in the second half of the first year.

Other DTCs referred to include:

- **Renewables sector** – Strathclyde University have just opened a Doctoral Training Centre for Wind
- **Ultrasonics** - Two PhD opportunities in Ultrasonics available, one practical and one theoretical. The studentships are available for 3.5 years duration and are registered for a PhD at University College London
- **Chemical engineering** – The DTC at Birmingham’s Chemical Engineering Department on hydrogen energy and formulation technology.

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88 Based on information from: [http://www.chm.bris.ac.uk/DTC/DTCs.htm](http://www.chm.bris.ac.uk/DTC/DTCs.htm) and [http://www.chm.bris.ac.uk/DTC/DTC_Presentation.pdf](http://www.chm.bris.ac.uk/DTC/DTC_Presentation.pdf)
Appendix F – Quantitative Research – Questionnaire
Good morning / afternoon. My name is ____________ from Swift Research. Please could I speak to <<name from database>>?

INTERVIEWER INSTRUCTION: IF NAMED CONTACT UNAVAILABLE MAKE AN APPOINTMENT TO CALL BACK

INTERVIEWER INSTRUCTION: WHEN SPEAKING TO THE NAMED CONTACT – CONTINUE

I am calling on behalf of DTZ who have been appointed by the Engineering & Physical Sciences Research Council (EPSRC) and Research Councils UK (RCUK) to conduct a study to develop quantitative and qualitative information on the value of doctoral level training. The main focus will be on PhDs in the physical sciences; such as chemistry, physics and maths; and also in the engineering disciplines and employers that employ postgraduates in these disciplines.

INTERVIEWER: ONLY READ OUT IF THE RESPONDENT ASKS FOR FURTHER INFORMATION ABOUT THE RESEARCH

The study will address three key questions:

- What do employers gain from doctorate holders and how does this differ from the value gained from holders of other qualifications, especially those with first degrees?
- In what ways do doctorate holders contribute to the competitiveness of their employers, both directly in terms of innovation and productivity benefits; and indirectly through supply chain linkages, customer and partner relationships?
- In what ways do doctorate holders contribute wider economic, environmental and societal benefits, for example, through the application of their knowledge and skills to bring about improvements in areas such as healthcare, energy provision, security, etc?

As part of this exercise, we would like to interview relevant personnel in your organisation to answer a number of questions to assist this study. Due to our requirement, to obtain perspectives from different parts of some organisations, we may be interviewing other personnel within your organisation.

Q.A. Do you have time to complete the interview now? It should take 10-15 minutes.

All responses will be anonymised and treated in the strictest confidence. Please note that all calls are recorded for quality control and training purposes.

Your participation in this study is very valuable and will help to guide EPSRC’s policy and planning in this area.

Yes  CONTINUE
No  ARRANGE A CALL BACK / SCHEDULE APPOINTMENT

INTERVIEWER – if YES, CONTINUE ..... 

INTERVIEWER – if NO, ASK QB
Q8. Please can we make an appointment to call you back at a more convenient time?

   Yes  ☐ MAKE APPOINTMENT

   No   ☐ THANK & CLOSE

INTERVIEWER - If YES make appointment in normal way, if NO, select refusal.

CLOSE OUT SCRIPT:

Many thanks for your time. If you have any questions about market research generally, then please call the Market Research Society freephone on 0500 396999.
Section 1 – Settling questions

**Question 1** What does your role in your organisation mainly concern?

INTERVIEWER / CATI NOTE: SINGLE CODE
CATI INSTRUCTION: Add other comments box

<table>
<thead>
<tr>
<th>R&amp;D (Technical)</th>
<th>R&amp;D (Management)</th>
<th>Other (please specify)</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
</tr>
</tbody>
</table>

**Question 2** This study is about the impact of doctorate holders. Would you feel comfortable answering about …?  

INTERVIEWER / CATI NOTE: SINGLE CODE
CATI INSTRUCTION: Add other comments box

<table>
<thead>
<tr>
<th>Your organisation as a whole</th>
<th>The R&amp;D function</th>
<th>Your business unit</th>
<th>Other (please specify)</th>
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</thead>
<tbody>
<tr>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
</tbody>
</table>

Section 2 – Importance of research and recruitment of doctorate holders

**Question 3** How important is research and innovation in your organisation for…?

INTERVIEWER / CATI NOTE: SINGLE CODE
INTERVIEWER: DO NOT READ OUT ‘NOT APPLICABLE’ AND ‘DON’T KNOW’ OPTIONS

<table>
<thead>
<tr>
<th></th>
<th>Q3a. Products/Services</th>
<th>Q3b. Processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Essential</td>
<td>□ 1</td>
<td>□ 1</td>
</tr>
<tr>
<td>Important</td>
<td>□ 2</td>
<td>□ 2</td>
</tr>
<tr>
<td>Not very important but helps</td>
<td>□ 3</td>
<td>□ 3</td>
</tr>
<tr>
<td>Not important</td>
<td>□ 4</td>
<td>□ 4</td>
</tr>
<tr>
<td>Not applicable</td>
<td>□ 5</td>
<td>□ 5</td>
</tr>
<tr>
<td>Don’t know</td>
<td>□ 6</td>
<td>□ 6</td>
</tr>
</tbody>
</table>

**Question 5a** Do you actively target doctorate holders in your recruitment exercises…?

INTERVIEWER / CATI NOTE: SINGLE CODE
INTERVIEWER: READ OUT OPTIONS
INTERVIEWER: DO NOT READ OUT ‘DON’T KNOW’ OPTION
CATI INSTRUCTION: IF CODES 3, 4 OR 5 ANSWERED AT Q5a(i) OR Q5a (ii) GO TO Q7

<table>
<thead>
<tr>
<th></th>
<th>Q5a(i). In your organisation as a whole</th>
<th>Q5a(ii) In your group/division</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes, actively target</td>
<td>□ 1 Go to Q5a(ii)</td>
<td>□ 1 Go to Q6a</td>
</tr>
<tr>
<td>Yes, actively target for specific jobs/roles</td>
<td>□ 2 Go to Q5a(ii)</td>
<td>□ 2 Go to Q6a</td>
</tr>
</tbody>
</table>
No, do not specifically target but a doctorate might help someone be recruited □ 3 Go to Q7 □ 3 Go to Q7
No, a PhD makes no difference in recruitment □ 4 Go to Q7 □ 4 Go to Q7
Don’t know □ 5 Go to Q7 □ 5 Go to Q7

Question 6a  Do you actively target any of the following particular types of doctorate and/or particular centres/universities?

INTERVIEWER: READ OUT OPTIONS
INTERVIEWER / CATI NOTE: MULTI CODE
CATI: ADD ‘OTHER’ TEXT BOX FOR STATEMENT 4

| Standard PhDs | □ 1 |
| PhDs completed in collaboration with industry, e.g. CASE | □ 2 |
| PhDs from a centre for doctoral training, e.g. EngD | □ 3 |
| PhDs from a specific university (please name and state reasons why e.g. location/quality/experience (alumnus?)) | □ 4 |
| None of the above | □ 5 |

Section 3 – Competencies of doctorate holders

ASK ALL

Question 7 Which types of functions/activities do doctorate holders carry out?

INTERVIEWER / CATI NOTE: MULTI CODE
CATI INSTRUCTION: Add other comments box

| Interface with external researchers, including academics | □ 1 |
| Providing consultancy services or external expertise on behalf of the organisation | □ 2 |
| Staff management | □ 3 |
| Providing internal expertise, e.g. Intellectual Property Rights, patent development, internal regulation (health & safety) | □ 4 |
| Other (please specify) | □ 5 |

Question 8 How important to your organisation are these competencies of doctorate holders?

INTERVIEWER / CATI NOTE: SINGLE CODE
INTERVIEWER NOTE: DO NOT READ OUT ‘NOT APPLICABLE’ OR ‘DON’T KNOW’ OPTIONS
CATI INSTRUCTION: ROTATE STATEMENTS

<table>
<thead>
<tr>
<th>Expertise specific to their</th>
<th>Very important</th>
<th>Fairly Important</th>
<th>Neither important nor unimportant</th>
<th>Fairly unimportant</th>
<th>Not at all important</th>
<th>Not applicable</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
<td>□ 5</td>
<td>□ 6</td>
<td>□ 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very important</td>
<td>Fairly important</td>
<td>Neither important nor unimportant</td>
<td>Fairly unimportant</td>
<td>Not at all important</td>
<td>Not applicable</td>
<td>Don’t know</td>
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<tr>
<td>PhD</td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Understanding of the broader subject of their PhD</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
<td>□ 5</td>
<td>□ 6</td>
<td>□ 7</td>
</tr>
<tr>
<td>Research skills/ methodologies</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
<td>□ 5</td>
<td>□ 6</td>
<td>□ 7</td>
</tr>
<tr>
<td>Data analysis abilities (including synthesis from diverse sources)</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
<td>□ 5</td>
<td>□ 6</td>
<td>□ 7</td>
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<tr>
<td>Problem solving skills</td>
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<td>□ 2</td>
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<td>□ 4</td>
<td>□ 5</td>
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<td>□ 7</td>
</tr>
<tr>
<td>Project management</td>
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<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
<td>□ 5</td>
<td>□ 6</td>
<td>□ 7</td>
</tr>
<tr>
<td>Ability to network</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
<td>□ 5</td>
<td>□ 6</td>
<td>□ 7</td>
</tr>
<tr>
<td>Business/commercial awareness</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
<td>□ 5</td>
<td>□ 6</td>
<td>□ 7</td>
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<tr>
<td>Communication</td>
<td>□ 1</td>
<td>□ 2</td>
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<td>□ 4</td>
<td>□ 5</td>
<td>□ 6</td>
<td>□ 7</td>
</tr>
<tr>
<td>Leadership/leadership potential: Business</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
<td>□ 5</td>
<td>□ 6</td>
<td>□ 7</td>
</tr>
<tr>
<td>Leadership/leadership potential: Research/Technology</td>
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<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
<td>□ 5</td>
<td>□ 6</td>
<td>□ 7</td>
</tr>
</tbody>
</table>
**Section 4 – Training**

**ASK ALL**  
*Question 11*  
Can you estimate the time taken for doctorate holders to adapt to their roles within the organisation on starting employment in comparison with other graduate groups?  
*INTERVIEWER / CATI NOTE: SINGLE CODE*  
*INTERVIEWER NOTE: DO NOT READ OUT ‘DON’T KNOW’ OPTION*

<table>
<thead>
<tr>
<th></th>
<th>□ 1</th>
<th>□ 2</th>
<th>□ 3</th>
<th>□ 4</th>
<th>□ 5</th>
<th>□ 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>It takes longer for doctorate holders to adapt to their roles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>It takes a similar time for doctorate holders to adapt to their roles</td>
<td>□ 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>It takes less time for doctorate holders to adapt to their roles</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Don’t know</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Question 12*  
In your organisation, how soon after starting will doctorate holders work in the following ways?  
*INTERVIEWER / CATI NOTE: SINGLE CODE*  
*INTERVIEWER NOTE: DO NOT READ OUT ‘DON’T KNOW’ OPTION*

<table>
<thead>
<tr>
<th></th>
<th>Rarely or not at all</th>
<th>From start date</th>
<th>Within 2-4 years</th>
<th>5-10 years</th>
<th>10+ years</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work autonomously</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
<td>□ 5</td>
<td>□ 6</td>
</tr>
<tr>
<td>Work at middle management level</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
<td>□ 5</td>
<td>□ 6</td>
</tr>
<tr>
<td>Work at senior management level</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
<td>□ 5</td>
<td>□ 6</td>
</tr>
</tbody>
</table>
## Section 5 – Impact of doctorate holders

**Question 13**  
What level of impact do doctorate holders have on increasing the following capabilities within your organisation, in terms of?

INTERVIEWER / CATI NOTE: SINGLE CODE  
INTERVIEWER NOTE: DO NOT READ OUT ‘DON’T KNOW’ OPTION  
CATI INSTRUCTION: ROTATE STATEMENTS

<table>
<thead>
<tr>
<th>Capability</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovation/creative thinking</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>Technical expertise</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>Problem-solving and trouble-shooting capabilities</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>Skills/productivity of other employees</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>Promotion of learning culture/ability of the organisation to learn about technological advances</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>Flows of knowledge within the company</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>Access to knowledge networks outside the company</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>Absorptive capacity (i.e. ability to identify and capture external information that can be used to improve the organisation’s processes and products)</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
</tbody>
</table>

**Question 13a**  
Do doctorate holders have an impact on increasing any other capabilities within your organisation?

Yes 1 Go to Q13aa  
No 2 Go to Q14  
Don’t know 3 Go to Q14

**Question 13aa**  
What other capabilities do doctorate holders increase within your organisation?

**Question 13b**  
What level of impact do doctorate holders have on this specific area?

<table>
<thead>
<tr>
<th>Other response from Q13aa</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
</tbody>
</table>
Question 14
What level of impact do doctorate holders have on the performance of your organisation in terms of?

INTERVIEWER / CATI NOTE: SINGLE CODE
INTERVIEWER NOTE: DO NOT READ OUT ‘DON’T KNOW’ or ‘NOT APPLICABLE’ OPTION

<table>
<thead>
<tr>
<th></th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Not applicable</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved commercial performance (e.g. in terms of improved turnover, profitability)</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
<td>□ 5</td>
</tr>
<tr>
<td>Improved position relative to competitors</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
<td>□ 5</td>
</tr>
</tbody>
</table>

Question 14a
Do doctorate holders have an impact on the performance of your organisation in any other areas?
Yes   1  Go to Q14aa
No    2  Go to Q15
Don’t know 3  Go to Q15

Question 14aa
Thinking about the performance of your organisation, what other areas do doctorate holders have an impact on?

Question 14b
What level of impact do doctorate holders have on this specific area?

INTERVIEWER NOTE: DO NOT READ OUT ‘DON’T KNOW’ or ‘NOT APPLICABLE’ OPTION

<table>
<thead>
<tr>
<th></th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Not applicable</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other response from Q14aa</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
<td>□ 5</td>
</tr>
</tbody>
</table>

Question 15
What level of impact do doctorate holders deliver outside your organisation in terms of?

INTERVIEWER / CATI NOTE: SINGLE CODE
INTERVIEWER NOTE: DO NOT READ OUT ‘DON’T KNOW’ OPTION

<table>
<thead>
<tr>
<th></th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>New knowledge or improved ways of doing things which are used by other companies in the same sector or area of business</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
<tr>
<td>New/enhanced products or processes which enable successful developments in other business areas (e.g. IT hardware/software)</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
</tbody>
</table>

Question 15a
Do doctorate holders deliver any other impacts outside your organisation?
Yes   1  Go to Q15aa
No    2  Go to Q16a
Don’t know 3  Go to Q16a
**Question 15aa**  What other impacts do doctorate holders deliver outside your organisation?

**Question 15b**  What level of impact do doctorate holders have on this specific area?

<table>
<thead>
<tr>
<th></th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other response from Q15aa</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
</tr>
</tbody>
</table>

**Question 16a**  What level of impact do doctorate holders within your organisation have on the delivery of the following areas?

**INTERVIEWER / CATI NOTE: SINGLE CODE**

**INTERVIEWER NOTE: DO NOT READ OUT ‘NOT APPLICABLE’ AND ‘DON’T KNOW’ OPTIONS**

**INTERVIEWER NOTE: IF RESPONDENT IS UNSURE, USE PROMPTS**

**CATI INSTRUCTION: ROTATE STATEMENTS**

<table>
<thead>
<tr>
<th>Area</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Not applicable</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>i) Policy/regulatory</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
<td>□ 5</td>
</tr>
<tr>
<td>INTERVIEWER: Prompt - through membership of government advisory/steering groups, regulatory bodies, consultations and policy development, including health, social, economic, industrial and energy. The impacts may be through the individual themselves or through the organisation, where the knowledge of the organisation is valued by policy makers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii) Standards/good practice</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
<td>□ 5</td>
</tr>
<tr>
<td>INTERVIEWER: Prompt - helping to establish benchmark standards in terms of management, processes that are adopted more widely by others</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii) Environmental</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
<td>□ 5</td>
</tr>
<tr>
<td>INTERVIEWER: Prompt - products or processes that offer benefits to the environment, such as greater energy efficiency, less pollution, greater use of sustainable materials, etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>iv) Health/quality of life</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
<td>□ 5</td>
</tr>
<tr>
<td>INTERVIEWER: Prompt - products or processes that offer health benefits, such as improved medicines, medical appliances, diagnostics, treatments, living aids, etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>v) Societal</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
<td>□ 5</td>
</tr>
<tr>
<td>INTERVIEWER: Prompt - products or processes that offer societal benefits in terms of greater security or better services in areas such as transport, energy, retail, etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>vi) Cultural</td>
<td>□ 1</td>
<td>□ 2</td>
<td>□ 3</td>
<td>□ 4</td>
<td>□ 5</td>
</tr>
<tr>
<td>INTERVIEWER: Prompt - products or processes that offer wider cultural benefits, such as developments in media and creative processes including CGI, games software, etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Question 16AA** Do doctorate holders have an impact on the delivery of any other areas within your organisation?

Yes 1 Go to Q16AAA

No 2 Go to Q16b

Don’t know 3 Go to Q16b

**Question 16AAA** What other areas within your organisation do doctorate holders have an impact on?

**Question 16AB** What level of impact do doctorate holders have on this specific area?

<table>
<thead>
<tr>
<th></th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Not applicable</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other response from Q16AAA</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

**Question 16b** You said that doctorate holders have a high level of impact within your organisation for the following areas…

[List all of questions coded as 1 from Q16a]

Could you provide me with some specific examples?

CATI INSTRUCTION: ONLY ASK FOR CODE 1 AT QUESTION 16ab(l-vii)
CATI INSTRUCTION: ADD NO COMMENTS BOX
INTERVIEWER: RECORD VERBATIM ACCURATELY USING PUNCTUATION MARKS (i.e. full stops, commas etc.) AND CLARIFY WHERE NECESSARY.
INTERVIEWER: PROBE ONCE USING / AND END THE PROBE WITH // IF RESPONDENT HAS NOTHING ELSE TO SAY AFTER PROBING ‘WHAT ELSE?’ TYPE IN ‘NOTHING’ AND END WITH //
**Question 17**  
Taking these types of impact together, what is the level of impact of doctorate holders delivered through their work in your organisation?

**INTERVIEWER / CATI NOTE: SINGLE CODE**  
**INTERVIEWER NOTE: DO NOT READ OUT ‘DON’T KNOW’ OPTION**

<table>
<thead>
<tr>
<th>From the outset</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>After initial training</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>After a couple of years of experience</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

**Question 18**  
To what extent do you think that STEM (Science, Technology, Engineering, & Mathematics) doctorate holders in the UK have general positive impacts in the following areas?

**INTERVIEWER / CATI NOTE: SINGLE CODE**  
**INTERVIEWER NOTE: DO NOT READ OUT ‘DON’T KNOW’ OPTION**  
**CATI INSTRUCTION: ROTATE STATEMENTS**

<table>
<thead>
<tr>
<th>Research (both capacity and knowledge advancement)</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Economic prosperity (i.e. the wider economy rather than in the organisation)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Education</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Policy/Standards</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Environmental</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Societal (including health &amp; well-being)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Cultural (including quality of life)</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

**Question 18a**  
Do STEM doctorate holders have a positive impact on any other areas?

Yes 1 Go to Q18aa  
No 2 Go to Q19  
Don’t know 3 Go to Q19

**Question 18aa**  
What are the other areas where STEM doctorate holders have a positive impact?

**Question 18b**  
What level of impact do STEM doctorate holders have on this specific area?

<table>
<thead>
<tr>
<th>Other response from Q18aa</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Don’t know</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

**Question 19**  
How likely is each of the following statements if your organisation could not recruit UK doctorate holders?

**INTERVIEWER / CATI NOTE: SINGLE CODE**  
**INTERVIEWER NOTE: DO NOT READ OUT ‘NOT APPLICABLE’ AND ‘DON’T KNOW’ OPTIONS**  
**CATI INSTRUCTION: ROTATE STATEMENTS**
Section 6 – Final questions

**Question 20**

Do you have any other comments that are relevant to our assessment of the impact of PhDs and their provision within a UK context?

**CATI INSTRUCTION: ADD NO COMMENTS BOX**

**INTERVIEWER: RECORD VERBATIM ACCURATELY USING PUNCTUATION MARKS (i.e. full stops, commas etc.) AND CLARIFY WHERE NECESSARY.**

**INTERVIEWER: PROBE ONCE USING / AND END THE PROBE WITH // IF RESPONDENT HAS NOTHING ELSE TO SAY AFTER PROBING 'WHAT ELSE?' TYPE IN 'NOTHING' AND END WITH //**

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

**Question 22**

Given that this study has been conducted under confidentiality rules, are there any specific comments that you would like to be passed to the EPSRC?

**CATI INSTRUCTION: ADD NO COMMENTS BOX**

**INTERVIEWER: RECORD VERBATIM ACCURATELY USING PUNCTUATION MARKS (i.e. full stops, commas etc.) AND CLARIFY WHERE NECESSARY.**

**INTERVIEWER: PROBE ONCE USING / AND END THE PROBE WITH // IF RESPONDENT HAS NOTHING ELSE TO SAY AFTER PROBING 'WHAT ELSE?' TYPE IN 'NOTHING' AND END WITH //**
Question 23  Would you agree to your full response being available (in confidence) to Research Council staff for analysis and policy development purposes?
Yes ☐  Go to Q24
No ☐  Skip Q24

Question 24  Thank you for your time and assistance. DTZ/Swift Research will report the anonymised results to EPSRC. Given the importance of the topic, it is likely that the Research Councils will want to follow-up some elements. Would you be happy to participate further?
Yes ☐ Clarify Name, Organisation, telephone number and email address
No ☐ Thank and close

INTERVIEWER:
That was my last question for today. Thank you for sparing me some time to give me your feedback. You may also receive an invitation from Swift to complete an online survey, please disregard this.

As I said my name is _________________ calling on behalf of DTZ.

If you have any questions about market research generally, then please call the Market Research Society freephone on 0500 396999.

Thank you again for your help.

END OF INTERVIEW
Appendix G – Quantitative research – survey results

Appendix G – Telephone and Web Survey Results
(Note: some question numbers are missing due to being eliminated from the earlier version to reduce survey length)

1. What does your role in your organisation mainly concern?

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;D (Technical)</td>
<td>28</td>
<td>24.8</td>
</tr>
<tr>
<td>R&amp;D (Management)</td>
<td>74</td>
<td>65.5</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td>6</td>
<td>5.3</td>
</tr>
<tr>
<td>Overall Responsibility i.e. CEO / Managing Director</td>
<td>3</td>
<td>2.7</td>
</tr>
<tr>
<td>Consultancy</td>
<td>2</td>
<td>1.8</td>
</tr>
<tr>
<td>Total</td>
<td>113</td>
<td>100.1</td>
</tr>
</tbody>
</table>

2. This study is about the impact of doctorate holders. Would you feel comfortable answering about ....?

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Your organisation as a whole</td>
<td>49</td>
<td>43.4</td>
</tr>
<tr>
<td>The R&amp;D function</td>
<td>35</td>
<td>31.0</td>
</tr>
<tr>
<td>Your business unit</td>
<td>29</td>
<td>25.7</td>
</tr>
<tr>
<td>Total</td>
<td>113</td>
<td>100.1</td>
</tr>
</tbody>
</table>

3. How important is research and innovation in your organisation for a) products/services and b) processes?

<table>
<thead>
<tr>
<th></th>
<th>3a. Frequency</th>
<th>3a. Percent</th>
<th>3b. Frequency</th>
<th>3b. Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Essential</td>
<td>87</td>
<td>77.0</td>
<td>41</td>
<td>36.3</td>
</tr>
<tr>
<td>Important</td>
<td>21</td>
<td>18.6</td>
<td>52</td>
<td>46.0</td>
</tr>
<tr>
<td>Not very important but helps</td>
<td>5</td>
<td>4.4</td>
<td>16</td>
<td>14.2</td>
</tr>
<tr>
<td>Not important</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1.8</td>
</tr>
<tr>
<td>Not applicable</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Don't know</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>1.8</td>
</tr>
<tr>
<td>Total</td>
<td>113</td>
<td>100</td>
<td>113</td>
<td>100.1</td>
</tr>
</tbody>
</table>
5a. Do you actively target doctorate holders in your recruitment exercises i) in your organisation as a whole and ii) in your group/division?

<table>
<thead>
<tr>
<th>5a(i) and 5a(ii)</th>
<th>5a(i). Frequency</th>
<th>5a(i). Percent</th>
<th>5a(ii). Frequency</th>
<th>5a(ii). Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes, actively target</td>
<td>20</td>
<td>17.70</td>
<td>23</td>
<td>20.35</td>
</tr>
<tr>
<td>Yes, actively target for specific jobs/roles</td>
<td>51</td>
<td>45.13</td>
<td>42</td>
<td>37.17</td>
</tr>
<tr>
<td>No, do not specifically target but a doctorate might help someone be recruited</td>
<td>34</td>
<td>30.09</td>
<td>5</td>
<td>4.42</td>
</tr>
<tr>
<td>No, a PhD makes no difference in recruitment</td>
<td>7</td>
<td>6.19</td>
<td>1</td>
<td>0.88</td>
</tr>
<tr>
<td>Don’t know</td>
<td>1</td>
<td>0.88</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>113</td>
<td>99.99</td>
<td>71</td>
<td>62.82</td>
</tr>
</tbody>
</table>

6a. Do you actively target any of the following particular types of doctorate holders and/or particular centres/universities? (Note – percent is from N=113. There were 151 boxes ticked.)

<table>
<thead>
<tr>
<th>6a</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard PhDs</td>
<td>49</td>
<td>43.4</td>
</tr>
<tr>
<td>PhDs completed in collaboration with industry, e.g. CASE</td>
<td>48</td>
<td>42.5</td>
</tr>
<tr>
<td>PhDs from a centre for doctoral training, e.g. EngD</td>
<td>29</td>
<td>25.7</td>
</tr>
<tr>
<td>PhDs from a specific university (please name and state reasons why e.g. location/quality/experience (alumnus?)</td>
<td>18</td>
<td>15.9</td>
</tr>
<tr>
<td>None of the above</td>
<td>7</td>
<td>6.2</td>
</tr>
<tr>
<td>Total</td>
<td>151</td>
<td>N/A</td>
</tr>
</tbody>
</table>
7. Which types of functions/activities do doctorate holders carry out?

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface with external researchers, including academics</td>
<td>98</td>
<td>86.7</td>
</tr>
<tr>
<td>Providing consultancy services or external expertise on behalf of the organisation</td>
<td>65</td>
<td>57.5</td>
</tr>
<tr>
<td>Staff management</td>
<td>62</td>
<td>62.0</td>
</tr>
<tr>
<td>Providing internal expertise, e.g. Intellectual Property Rights, patent development, internal regulation (health &amp; safety)</td>
<td>85</td>
<td>75.2</td>
</tr>
<tr>
<td>Other</td>
<td>17</td>
<td>15.0</td>
</tr>
<tr>
<td>Internal Research</td>
<td>5</td>
<td>4.4</td>
</tr>
<tr>
<td>Research &amp; Development (Unspecified)</td>
<td>10</td>
<td>8.8</td>
</tr>
<tr>
<td>Specific to their area of expertise</td>
<td>5</td>
<td>4.4</td>
</tr>
<tr>
<td>Total</td>
<td>347</td>
<td>N/A</td>
</tr>
</tbody>
</table>
8. How important to your organisation are these competencies of doctorate holders?

<table>
<thead>
<tr>
<th>Competency</th>
<th>Frequency</th>
<th>Very important</th>
<th>Fairly important</th>
<th>Neither important nor unimportant</th>
<th>Fairly unimportant</th>
<th>Not at all important</th>
<th>Not applicable</th>
<th>Don't know</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expertise specific to their PhD</td>
<td>113</td>
<td>41</td>
<td>49</td>
<td>19</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Understanding of the broader subject of their PhD</td>
<td>113</td>
<td>47</td>
<td>53</td>
<td>12</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Research skills/methodologies</td>
<td>100</td>
<td>71</td>
<td>36</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Data analysis abilities (including synthesis from diverse sources)</td>
<td>113</td>
<td>63</td>
<td>39</td>
<td>6</td>
<td>4</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Problem solving skills</td>
<td>113</td>
<td>85</td>
<td>22</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Project management</td>
<td>113</td>
<td>20</td>
<td>60</td>
<td>23</td>
<td>7</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Ability to network</td>
<td>113</td>
<td>35</td>
<td>55</td>
<td>17</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Business/commercial awareness</td>
<td>113</td>
<td>16</td>
<td>54</td>
<td>36</td>
<td>4</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>113</td>
<td>67</td>
<td>40</td>
<td>5</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Leadership/leadership potential: Business</td>
<td>113</td>
<td>8</td>
<td>52</td>
<td>44</td>
<td>6</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Leadership/leadership potential: Research/Technology</td>
<td>113</td>
<td>49</td>
<td>51</td>
<td>13</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>113</td>
<td>41</td>
<td>49</td>
<td>19</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>
11. Can you estimate the time taken for doctorate holders to adapt to their roles within the organisation on starting employment in comparison with other graduate groups?

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>It takes longer for doctorate holders to adapt to their roles</td>
<td>5</td>
<td>4.4</td>
</tr>
<tr>
<td>It takes a similar time for doctorate holders to adapt to their roles</td>
<td>61</td>
<td>54.0</td>
</tr>
<tr>
<td>It takes less time for doctorate holders to adapt to their roles</td>
<td>43</td>
<td>38.1</td>
</tr>
<tr>
<td>Don't know</td>
<td>4</td>
<td>3.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>113</strong></td>
<td>100</td>
</tr>
</tbody>
</table>

12. In your organisation, how soon after starting will doctorate holders work in the following ways?

<table>
<thead>
<tr>
<th></th>
<th>Rarely or not at all</th>
<th>From start date</th>
<th>Within 2-4 years</th>
<th>5-10 years</th>
<th>10+ years</th>
<th>Don't know</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work Autonomously</td>
<td>Frequency</td>
<td>1</td>
<td>70</td>
<td>40</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>0.9</td>
<td>61.9</td>
<td>35.4</td>
<td>0</td>
<td>0</td>
<td>1.8</td>
</tr>
<tr>
<td>Work at middle management level</td>
<td>Frequency</td>
<td>0</td>
<td>9</td>
<td>52</td>
<td>44</td>
<td>2</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>0.0</td>
<td>8.0</td>
<td>46.0</td>
<td>38.9</td>
<td>1.8</td>
<td>5.3</td>
</tr>
<tr>
<td>Work at senior management level</td>
<td>Frequency</td>
<td>3</td>
<td>4</td>
<td>14</td>
<td>40</td>
<td>44</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>2.7</td>
<td>3.5</td>
<td>12.4</td>
<td>35.4</td>
<td>38.9</td>
<td>7.1</td>
</tr>
</tbody>
</table>

13. What level of impact do doctorate holders have on increasing the following capabilities within your organisation, in terms of?

<table>
<thead>
<tr>
<th></th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Don't know</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Innovative/creative thinking</td>
<td>Frequency</td>
<td>85</td>
<td>28</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>75.2</td>
<td>24.8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Technical expertise</td>
<td>Frequency</td>
<td>94</td>
<td>19</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>83.2</td>
<td>16.8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Problem-solving and trouble-shooting capabilities</td>
<td>Frequency</td>
<td>77</td>
<td>34</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>68.1</td>
<td>30.1</td>
<td>1.8</td>
<td>0</td>
</tr>
<tr>
<td>Skills/productivity of other employees</td>
<td>Frequency</td>
<td>24</td>
<td>57</td>
<td>29</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>21.2</td>
<td>50.4</td>
<td>25.7</td>
<td>2.7</td>
</tr>
<tr>
<td>Promotion of learning culture/ability of the organisation to learn about technological advances</td>
<td>Frequency</td>
<td>47</td>
<td>58</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>41.6</td>
<td>51.3</td>
<td>7.1</td>
<td>0</td>
</tr>
<tr>
<td>Flows of knowledge within the company</td>
<td>Frequency</td>
<td>49</td>
<td>52</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>43.4</td>
<td>46.0</td>
<td>10.6</td>
<td>0</td>
</tr>
<tr>
<td>Access to knowledge networks outside the company</td>
<td>Frequency</td>
<td>52</td>
<td>53</td>
<td>8</td>
<td>0</td>
</tr>
</tbody>
</table>
### Absorptive capacity (i.e. Ability to identify and capture external information that can be used to improve the organisation's processes and products)

<table>
<thead>
<tr>
<th></th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Don't know</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Percent</strong></td>
<td>46.0</td>
<td>46.9</td>
<td>7.1</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td>64</td>
<td>44</td>
<td>5</td>
<td>0</td>
<td>113</td>
</tr>
<tr>
<td><strong>Percent</strong></td>
<td>56.6</td>
<td>38.9</td>
<td>4.4</td>
<td>0</td>
<td>99.9</td>
</tr>
</tbody>
</table>

### 14. What level of impact do doctorate holders have on the performance of your organisation in terms of?

<table>
<thead>
<tr>
<th>14</th>
<th>Improved commercial performance (e.g. In terms of improved turnover, profitability)</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Not applicable</th>
<th>Don't know</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>28</td>
<td>55</td>
<td>19</td>
<td>5</td>
<td>6</td>
<td>113</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>24.8</td>
<td>48.7</td>
<td>16.8</td>
<td>4.4</td>
<td>5.3</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Improved position relative to competitors</td>
<td>Frequency</td>
<td>45</td>
<td>49</td>
<td>9</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>39.8</td>
<td>43.4</td>
<td>8.0</td>
<td>6.2</td>
<td>2.7</td>
<td>100.1</td>
</tr>
</tbody>
</table>

### 15. What level of impact do doctorate holders deliver outside your organisation in terms of?

<table>
<thead>
<tr>
<th>15</th>
<th>New knowledge or improved ways of doing things which are used by other companies in the same sector or area of business</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Don't know</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>27</td>
<td>60</td>
<td>22</td>
<td>4</td>
<td>113</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>23.9</td>
<td>53.1</td>
<td>19.5</td>
<td>3.5</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>New/enhanced products or processes which enable successful developments in other business areas (e.g. IT hardware/software)</td>
<td>Frequency</td>
<td>21</td>
<td>54</td>
<td>29</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>18.6</td>
<td>47.8</td>
<td>25.7</td>
<td>8.0</td>
<td>100.1</td>
</tr>
</tbody>
</table>

### 16a. What level of impact do doctorate holders within your organisation have on the delivery of the following areas?

<table>
<thead>
<tr>
<th>16a</th>
<th>Policy/regulatory</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Not applicable</th>
<th>Don't know</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Frequency</td>
<td>24</td>
<td>43</td>
<td>36</td>
<td>7</td>
<td>3</td>
<td>113</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>21.2</td>
<td>38.1</td>
<td>31.9</td>
<td>6.2</td>
<td>2.7</td>
<td>100.1</td>
</tr>
<tr>
<td></td>
<td>Standards/good practice</td>
<td>Frequency</td>
<td>26</td>
<td>56</td>
<td>22</td>
<td>7</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>23.0</td>
<td>49.6</td>
<td>19.5</td>
<td>6.2</td>
<td>1.8</td>
<td>100.1</td>
</tr>
<tr>
<td></td>
<td>Environmental</td>
<td>Frequency</td>
<td>20</td>
<td>49</td>
<td>27</td>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>17.7</td>
<td>43.4</td>
<td>23.9</td>
<td>12.4</td>
<td>2.7</td>
<td>100.1</td>
</tr>
<tr>
<td></td>
<td>Health/quality of life</td>
<td>Frequency</td>
<td>30</td>
<td>28</td>
<td>30</td>
<td>21</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Percent</td>
<td>26.5</td>
<td>24.8</td>
<td>26.5</td>
<td>18.6</td>
<td>3.5</td>
<td>99.9</td>
</tr>
</tbody>
</table>
17. Taking these types of impact together, what is the level of impact of doctorate holders delivered through their work in your organisation?

<table>
<thead>
<tr>
<th></th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Not applicable</th>
<th>Don’t know</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Societal</strong></td>
<td>10</td>
<td>43</td>
<td>30</td>
<td>23</td>
<td>7</td>
<td>113</td>
</tr>
<tr>
<td><strong>Percent</strong></td>
<td>8.8</td>
<td>38.1</td>
<td>26.5</td>
<td>20.4</td>
<td>6.2</td>
<td>100</td>
</tr>
<tr>
<td><strong>Cultural</strong></td>
<td>8</td>
<td>32</td>
<td>33</td>
<td>35</td>
<td>5</td>
<td>113</td>
</tr>
<tr>
<td><strong>Percent</strong></td>
<td>7.1</td>
<td>28.3</td>
<td>29.2</td>
<td>31.0</td>
<td>4.4</td>
<td>100</td>
</tr>
</tbody>
</table>

18. To what extent do you think that STEM (Science, Technology, Engineering, & Mathematics) doctorate holders in the UK have general positive impacts in the following areas?

<table>
<thead>
<tr>
<th></th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Don’t Know</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Research (both capacity and knowledge advancement)</strong></td>
<td>88</td>
<td>20</td>
<td>1</td>
<td>4</td>
<td>113</td>
</tr>
<tr>
<td><strong>Percent</strong></td>
<td>77.9</td>
<td>17.7</td>
<td>.9</td>
<td>3.5</td>
<td>100</td>
</tr>
<tr>
<td><strong>Economic prosperity (i.e. The wider economy rather than in the organisation)</strong></td>
<td>46</td>
<td>54</td>
<td>5</td>
<td>8</td>
<td>113</td>
</tr>
<tr>
<td><strong>Percent</strong></td>
<td>40.7</td>
<td>47.8</td>
<td>4.4</td>
<td>7.1</td>
<td>100</td>
</tr>
<tr>
<td><strong>Education</strong></td>
<td>58</td>
<td>43</td>
<td>4</td>
<td>8</td>
<td>113</td>
</tr>
<tr>
<td><strong>Percent</strong></td>
<td>51.3</td>
<td>38.1</td>
<td>3.5</td>
<td>7.1</td>
<td>100</td>
</tr>
<tr>
<td><strong>Policy/Standards</strong></td>
<td>22</td>
<td>55</td>
<td>22</td>
<td>14</td>
<td>113</td>
</tr>
<tr>
<td><strong>Percent</strong></td>
<td>19.5</td>
<td>48.7</td>
<td>19.5</td>
<td>12.4</td>
<td>100.1</td>
</tr>
<tr>
<td><strong>Environmental</strong></td>
<td>41</td>
<td>38</td>
<td>17</td>
<td>17</td>
<td>113</td>
</tr>
<tr>
<td><strong>Percent</strong></td>
<td>36.3</td>
<td>33.6</td>
<td>15.0</td>
<td>15.0</td>
<td>99.9</td>
</tr>
<tr>
<td><strong>Societal (including health &amp; well-being)</strong></td>
<td>28</td>
<td>47</td>
<td>24</td>
<td>14</td>
<td>113</td>
</tr>
<tr>
<td><strong>Percent</strong></td>
<td>24.8</td>
<td>41.6</td>
<td>21.2</td>
<td>12.4</td>
<td>100</td>
</tr>
<tr>
<td><strong>Cultural (including quality of life)</strong></td>
<td>12</td>
<td>55</td>
<td>31</td>
<td>15</td>
<td>113</td>
</tr>
<tr>
<td><strong>Percent</strong></td>
<td>10.6</td>
<td>48.7</td>
<td>27.4</td>
<td>13.3</td>
<td>100</td>
</tr>
</tbody>
</table>
19. How likely is each of the following statements if your organisation could not recruit UK doctorate holders?

<table>
<thead>
<tr>
<th>19</th>
<th>Very likely</th>
<th>Likely</th>
<th>Neither likely nor unlikely</th>
<th>Not very likely</th>
<th>Not at all likely</th>
<th>Not applicable</th>
<th>Don't know</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>We would be unable to maintain our current competitive position and performance would be poorer</td>
<td>Frequency</td>
<td>29</td>
<td>38</td>
<td>22</td>
<td>12</td>
<td>7</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Percent</td>
<td>25.7</td>
<td>33.6</td>
<td>19.5</td>
<td>10.6</td>
<td>6.2</td>
<td>1.8</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>We would seek to outsource our research locally - i.e. in the UK</td>
<td>Frequency</td>
<td>10</td>
<td>33</td>
<td>31</td>
<td>23</td>
<td>12</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Percent</td>
<td>8.8</td>
<td>29.2</td>
<td>27.4</td>
<td>20.4</td>
<td>10.6</td>
<td>2.7</td>
<td>.9</td>
<td></td>
</tr>
<tr>
<td>We would seek to outsource our research anywhere in the world</td>
<td>Frequency</td>
<td>18</td>
<td>33</td>
<td>17</td>
<td>26</td>
<td>15</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Percent</td>
<td>15.9</td>
<td>29.2</td>
<td>15.0</td>
<td>23.0</td>
<td>13.3</td>
<td>2.7</td>
<td>.9</td>
<td></td>
</tr>
<tr>
<td>We would relocate our R&amp;D activities to a country other than the UK</td>
<td>Frequency</td>
<td>18</td>
<td>21</td>
<td>21</td>
<td>25</td>
<td>24</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Percent</td>
<td>15.9</td>
<td>18.6</td>
<td>18.6</td>
<td>22.1</td>
<td>21.2</td>
<td>2.7</td>
<td>.9</td>
<td></td>
</tr>
</tbody>
</table>