The Economic Impact of PhDs

Engineering & Physical Science Research Council (EPSRC)
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1. Introduction

1.1 Study background

DTZ was commissioned by the EPSRC to undertake a study to measure the economic impact on the value of PhDs.

The purpose of this study is to help the EPSRC to better understand and articulate the benefits resulting from its investment in PhD training in order to enable it to justify its spend on science and engineering and to inform where best value is being achieved. There is an increasing emphasis placed on quantified and monetised outcomes from such investment, as well as assessing the wider benefits to the economy and society.

The study has to address 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.

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 essential to understand what these students go on to do, and what impact their qualifications have.

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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)
Research Councils in the UK 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.

It is important to develop an understanding of PhD value, to consider what subjects are most in demand and how the skills and activities of students are used. It is also important to consider the extent to which the specific skills of science and numerate PhD students are demanded in relation to their supply and how this compares with other PhD subjects. Similarly, there needs to be an understanding of what value is added by having a doctorate compared to an undergraduate degree.

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 PhD scholarships that they fund. Fundamental to this, is developing an understanding of what PhD students go on to do in the labour market and by what routes.

There already exists a large body of literature relating to PhD students and their destinations, 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 PhDs. 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 PhDs, the values employers attach to PhDs, and the roles PhD graduates play in their employing organisations. Such information is vital to gain a fuller and more accurate picture of the impact of PhDs in the UK economy and society.

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

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, each of which is described in detail below.

- 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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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 PhDs: A Logic Model

The Nature & Scale of Impact

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

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

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

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

1.2 Study method

The study method was discussed and agreed with the client at project inception. It needed sufficient flexibility to be adapted as the study progressed.

The study was 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 PhD graduates entering non-academic employment. It also involved a pilot survey, after consultations with relevant stakeholders, on how impact is being generated by these graduates and on good practice. This included a number of interviews with organisations and organisational representative bodies.

This is to inform the second phase of the study, which will involve a wider survey of employers to identify, more broadly, the impact of PhD graduates across a range of employers/sectors. Particularly interesting case studies would be identified in Phase 1, with more detailed primary research undertaken in Phase 2 to explore some of the key issues in further detail.

In summary:

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

- Phase 2 provides 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 was to allow our understanding of impacts to be developed as the study continued, and enable us to identify the areas in which the study needs 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.

This report is based on the Phase 1 results as well as the implications and recommendations for Phase 2.

Figure 1.2 provides an illustration of the main stages in Phase 1 of the study.
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.

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 and 3).
2. Literature review

Key findings

- 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.
- 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.
- However, academia is the largest employment sector as a first destination of these 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.
- 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.
- Possible wider impacts, e.g. to the economy and society, are more difficult to identify and quantify.

2.1 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 (to be carried out in Phase 2).

The literature review has informed the 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, e.g. on the uptake and impact of PhDs in a number of economic sectors, 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, international and national, 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 was agreed with the project Steering Group. 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. These sources can be broken down into four main categories.
• 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).

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
   o Supply
   o Destinations
2. Employment
   o Employer demand
   o Skills for employment
   o Barriers to employment
3. Impact
   o Individual impact
   o Employer impact
   o Social impact
4. Conclusions

2.2 PhD graduates and their destinations

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

2.2.1 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%.\(^5\)

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.\(^6\) The total stock of EPSRC funded studentships in April 2007 was 7,903.\(^7\)

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 &

\(^{5}\) What Do PhDs Do?, UK GRAD Programme, Careers Research and Advisory Centre, 2004
\(^{6}\) What do researchers do? Vitae, 2009
\(^{7}\) 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.
technology FTEs increased by 8%. 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%.

**Figure 2.1 UK-domiciled doctoral graduate population by subject 2003-2007**

![Diagram showing subject areas and their shares](image)

Source: What do researchers do?

### 2.2.2 Destinations

The Roberts Review (2002) found that, based on the Labour Force Survey (LFS), for 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. This means that a higher share of these postgraduates is either working or seeking employment.

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’s, from 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.

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8 Postgraduate Education in the United Kingdom, Higher Education Policy Institute and The British Library, January 2010

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

**Figure 2.2 Occupations of PhD graduates of 2003-2007 by academic discipline**

![Bar chart showing occupations of PhD graduates by discipline]

Source: Vitae, What Do Researchers Do?, 2009

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.

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10 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.
• 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, e.g. the burden of jobs cuts and recruitment freezes have fallen on the private sector to date.\textsuperscript{11}

• 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.\textsuperscript{12}

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.

\textsuperscript{11} See recent paper from Confederation of British Industry (CBI) and Price Waterhouse Coopers http://www.cbi.org.uk/ndbs/press.nsf/0363c1f07b6ca12a8025671c00381cc7/d6f27e4b399250680257693003f232c?OpenDocument
\textsuperscript{12} Where do EPSRC Students Go? A Study of Career Paths, Planning & Communication Division, Dunn, M. and Hemmings, P., Engineering and Physical Sciences Research Council, 2000
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 2.1 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 2.1 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
2.3 Employment

This sub section considers the basis for employer demand for PhD 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.

2.3.1 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.¹³

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.¹⁴ 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. Destination results from earlier sections 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.

A forecasting study was carried out in Australia for the Federal Department of Innovation, Industry, Science and Research, mapping likely future demand for PhDs¹⁵. As with many of the UK sources, doctorate qualified individuals could not be identified as a separate group.

¹⁴ The Role of PhDs in the Smart Economy, Forfas/Advisory Science Council, December 2009
¹⁵ D. Edwards, The future of the research workforce: estimating demand for PhDs in Australia, Journal of Higher Education Policy and Management, 32: 2, 199 — 210, 2010
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%.

The sectors with highest demand were those where there are a range of positions related to research, including post-school education (8%), scientific research (42%), government administration (59%) and technical services (59%). These are not broken down into constituent parts, so it is not possible to see which industries the scientific and technical workers are expected to work in.

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.

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

The Roberts Review also 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 sciences-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 study in 1999 surveyed EPSRC funded PhD students and staff in receipt of research awards. It found that 30-40% of the 127 PhD survey respondents had continued in a research post with either HE or industry.

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

1. Personal skills

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17 D. Edwards, The future of the research workforce: estimating demand for PhDs in Australia, Journal of Higher Education Policy and Management, 32: 2, 199 — 210, 2010
19 What Do PhDs Do?, UK GRAD Programme, Careers Research and Advisory Centre, 2004
21 Survey of employer attitudes to postgraduate researchers, Prospects, August 2006
2. Communication  
3. Research skills  
4. Project management skills  
5. Teamwork  
6. Job related  
7. Career management

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 2.2 outlines these identified skills.

Table 2.2 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.

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 business. 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 2.3 highlights the overall findings of the survey.

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22 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  
23 Survey of employer attitudes to postgraduate researchers, Prospects, August 2006  
24 Talent Fishing – What Businesses Want from Postgraduates, CIHE report for BIS, 2010
Table 2.3 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

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

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 helps 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.
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.

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.

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25 Talent Fishing – What Businesses Want from Postgraduates, CIHE report for BIS, 2010
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 where 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.

2.3.3 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

It is 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

27 Attraction & Retention of Staff & Students in Research in IT & Computer Science, Engineering and Physical Sciences Research Council, May 1999
28 Recruiting PhDs – What works? The UK Grad Programme, March 2007
employers do not perceive them to be different. The study 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.

2.4 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, e.g. impacts that benefit individuals may also benefit their employers and wider society.

Figure 2.4 Overview of impacts of PhD graduates

Source: DTZ

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29 Recruiting PhDs – What works? The UK Grad Programme, March 2007
30 The Role of PhDs in the Smart Economy, Forfas/Advisory Science Council, December 2009
31 Survey of employer attitudes to postgraduate researchers, Prospects, August 2006
2.4.1 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.32

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.33 The table, below, highlights their findings. For both males and females the wage premia is greater for doctoral graduates.

Table 2.4 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)

However, they also found that the rate of return appears to be lower for engineering and technology PhD graduates compared to many of the other subjects (see Table 2.5, below). For men and women, 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.

33 O’Leary & Sloane, The Return to a University Education in Great Britain, National Institute Economic Review, No. 193, July, 2005
Table 2.5 Individual rate of return by PhD subject area

<table>
<thead>
<tr>
<th>Subject</th>
<th>n</th>
<th>Rate of return - Male</th>
<th>n</th>
<th>Rate of return – Female</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medicine and related</td>
<td>100</td>
<td>0.1781*</td>
<td>59</td>
<td>0.1459*</td>
</tr>
<tr>
<td>Sciences</td>
<td>528</td>
<td>0.0785*</td>
<td>174</td>
<td>0.1419*</td>
</tr>
<tr>
<td>Maths and computing</td>
<td>75</td>
<td>0.0478</td>
<td>10</td>
<td>0.1239*</td>
</tr>
<tr>
<td>Engineering and technology</td>
<td>131</td>
<td>0.0497</td>
<td>8</td>
<td>0.0350</td>
</tr>
<tr>
<td>Architecture and related</td>
<td>4</td>
<td>-0.0656</td>
<td>1</td>
<td>N/A</td>
</tr>
<tr>
<td>Social sciences</td>
<td>72</td>
<td>0.0750**</td>
<td>52</td>
<td>0.1427**</td>
</tr>
<tr>
<td>Business and financial studies</td>
<td>12</td>
<td>0.2021*</td>
<td>6</td>
<td>0.1080*</td>
</tr>
<tr>
<td>Arts</td>
<td>107</td>
<td>0.0448</td>
<td>50</td>
<td>0.0845**</td>
</tr>
<tr>
<td>Languages</td>
<td>9</td>
<td>0.0119</td>
<td>9</td>
<td>0.0662</td>
</tr>
<tr>
<td>Education</td>
<td>13</td>
<td>-0.0099</td>
<td>12</td>
<td>0.1239*</td>
</tr>
<tr>
<td>Combined</td>
<td>109</td>
<td>0.1116*</td>
<td>42</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.34

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.35 These rates were estimated to be higher compared to graduates of humanities and social sciences.

Table 2.6 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.

34 A study on rates of return to investment in Level 3 and higher qualifications, Warwick Institute for Employment Research, November 2005
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.

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. While social impacts have also been considered in some reviews, fewer studies have however focused on the employer impacts.

### 2.4.2 Employer impact

The Leitch Review recognised that postgraduate skills levels are one of the most influential parameters for improving productivity. 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.

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36 STEM Review – the Science, Technology, Engineering, Maths Supply Chain, CIHE, March 2007
37 STEM Review – the Science, Technology, Engineering, Maths Supply Chain, CIHE, March 2007
38 Recruiting PhDs – What works? The UK Grad Programme, March 2007
39 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
40 Survey of employer attitudes to postgraduate researchers, Prospects, August 2006
41 Skills, Knowledge and Organisational Performance (SKOPE), University of Oxford
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.\(^{43}\)

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.\(^{44}\) 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.\(^{45}\)

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.\(^{46}\)

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.\(^{47}\) 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

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\(^{45}\) Survey of employer attitudes to postgraduate researchers, Prospects, August 2006

\(^{46}\) Employers’ perceptions of recruiting research staff and students, Prospect

\(^{47}\) Recruiting PhDs – What works? The UK Grad Programme, March 2007
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.48

Interestingly, it was found that those employers or managers who recruited PhD graduates tended to have PhDs themselves.49 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.

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).50 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.

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.51 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

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48 Employers’ perceptions of recruiting research staff and students, Prospect
49 Recruiting PhDs – What works? The UK Grad Programme, March 2007
50 Recruiting PhDs – What works? The UK Grad Programme, March 2007
51 The Role of PhDs in the Smart Economy, Forfas/Advisory Science Council, December 2009
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.  

In summary, 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.

2.4.3 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 2.7, 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.

52 The Role of PhDs in the Smart Economy, Forfas/Advisory Science Council, December 2009
53 Larkins The Economic Benefits of Australian University Degrees: Bachelor and Research Higher Degrees, Australia Economic Review 34(4), 2001
Table 2.7 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.

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

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54 *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.

55 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.

56 Research Councils UK: Pathways to Impact [http://impacts.rcuk.ac.uk/default.htm](http://impacts.rcuk.ac.uk/default.htm)
• Evidence based policy-making and influencing public policy
• Increasing public engagement with research and related societal issues.

2.5 Conclusions

The 2006 Leitch Review\textsuperscript{57} stressed the importance of skills to the UK economy, particularly in raising productivity. According to Leitch, productivity can be raised through education:

- directly, by increasing human capital in a firm or country;
- indirectly, by ‘spillover’ impacts on the productivity of other workers; and
- via other drivers, by encouraging greater investment and innovation.

When compared to other countries, the UK has a relatively large, and growing, number of doctoral students studying for scientific and technical qualifications. However, according to the Roberts Review:

\textit{“...this growth is primarily due to increases in the numbers studying IT and the biological sciences, with the overall increase masking downward trends in the numbers studying mathematics, engineering and the physical sciences.”}\textsuperscript{58}

The findings of our literature review highlight that there still exists a significant gap in our knowledge about the actual impacts that PhD graduates are having within their organisations. Clearly, evidence shows that these graduates are having impact and are in demand, but negative perceptions can stand in the way of their recruitment, especially where organisations are not already familiar with PhD graduate attributes and contribution.

Companies that do employ PhD graduates, whether specifically or as part of general graduate recruitment, can expect to benefit from their recruitment in a range of ways. This can include factors such as higher levels of innovation, absorptive capacity, rapid return on investment, recruitment and training, and potential to create future leaders. The generation of such factors can be seen as essential in companies seeking to compete in more challenging economic times.

The CIHE study on the value of graduates and postgraduates also agrees that there are significant gaps in existing research evidence on graduate value to organisations.\textsuperscript{59} For example, no research seems to exist that compares the impact between graduates of first degrees and those of PhD degrees for the employer. Evidence on linkages between business performance and higher degrees within the workforce is also lacking. Reasons for this are linked to a weak evidence base among employers on graduate value and tracking of individuals through their careers.

Issues raised in the literature that relate to perceived negative attributes of PhD graduates may have some grounding in reality, but there also appears to be a strong level of perception, particularly given these are more likely to occur among employers that have no experience of employing PhD graduates. As well as a need for further research into employer perceptions and experiences, this might suggest a role for Research Councils such as EPSRC in

\textsuperscript{57} Prosperity for all in the global economy - world class skills, \textit{Leitch Review of Skills}, 2006
\textsuperscript{58} SET for Success, \textit{The supply of people with science, technology, engineering and mathematics skills}, The report of the \textit{Sir Gareth Roberts Review}, 2002
\textsuperscript{59} The Value of Graduates and Postgraduates, CIHE, November 2009
promoting understanding and awareness of the value of its funded PhD graduates and the realities of working with them. A further recommendation for practice may be that, where a company has no experience of recruiting PhD graduates, an individual in the industry who has a PhD could act as a form of ‘ambassador’, being involved in the recruitment processes.

A further issue seems to be that students or graduates themselves are not aware of alternative careers or the skill requirements in industry. They can overlook some of the skills they possess and do not articulate these effectively to employers. This means that there is a mismatch between skills demanded and skills held. Further information and guidance to students would help this problem of information failure and help students to understand how to communicate their transferable skills to potential employers.
3. Consultations

Key findings

Employer focus. If the organisation was not engaged in research, then the interview tended to have limited relevance for them and it generated no significant value to the study. The vast majority of employers were research focused (14 out of 19) and it was the feedback from this cohort that informed our assessment of impact in the pilot study. There were no other functional roles undertaken by PhD graduates that could be interrogated to determine the nature of impact and the underpinning transmission mechanism.

Sectoral profile. The main research functions were undertaken in innovation intensive industries: pharmaceuticals, advanced manufacturing, chemicals and energy.

The following key management aspects are managed proactively by research based organisations to attract, remunerate, train and develop the most able PhD graduates to maximise their impact.

- Recruitment & competencies
- Remuneration
- Career progression
- Training.

Impact assessment. Given the research focus in the employer sample, it is not surprising that the main areas of impact relate to innovation, new product development and the associated intellectual property, as well as the commercial benefits that flow from these activities.

Out of the 19 employers, 16 either directly or indirectly attributed positive impacts through the employment of PhD graduates. Furthermore, those responding rated impact as either ‘high’ or ‘very high’. The survey generated a significant amount of qualitative evidence in support of the research and commercial impact for employers, generally supporting the findings from the literature review. However, there was more limited information on wider impacts. The main indirect impacts quoted related to the beneficial contribution to other research bodies and universities through knowledge exchange and ‘open innovation’. There was very little discussion of wider spillover benefits relating to other partner companies, supply chains or government. There was some corroboration of these findings from consultations with the umbrella bodies, but a number of these were not as knowledgeable about impact of PhD holders and, within this sample, some were noticeably ‘cooler’ about their impact.

Lessons learned

In order of ease of assessing impact, it appears that direct impact is the easiest for employers to describe, followed by the transmission mechanism, indirect impacts and, finally, wider impacts.

Research functions vs. non-research functions. It is much easier for employers to identify and explain impact when PhD graduates are recruited for specific research functions with a scientific, technical or IT focus. Our expectation is that it will be difficult in the Phase 2 survey to identify PhD employers in non-research functions and for them to articulate the nature and
contribution of the impact that PhD graduates generate for them.

*Impact type vs. impact process.* It is much easier for employers to describe the nature of impacts that PhD graduates can generate than explain the transmission mechanisms through which such impacts are generated.

*Direct vs. indirect impact.* It is much easier to try and explain the transmission mechanism for employers (even if it is difficult for them to attribute impact to PhDs in quantitative or measurable terms), than it is for wider indirect and spillover impacts on third parties.

## 3.1 Introduction

The purpose of this stage was four-fold.

1. To collect relevant information/data held centrally by the EPSRC and other stakeholders, particularly material that is not publicly available.

2. To conduct exploratory interviews with a range of institutions to understand the nature of their investment in PhDs and what this investment is producing.

3. To discuss with a wider range of bodies, including employer representative organisations, about the impacts that are being achieved by PhD graduates in the workplace, as well as areas of good practice and for improvement.

4. To identify suitable sectors/organisations with which to conduct further research in the remaining stages of the study.

A list of the bodies consulted is provided in Appendix B. We attempted to target those sectors of most interest to the EPSRC. The bodies to contact were agreed in advance with the EPSRC, as were the topic guides on which the interviews were based. These topic guides are presented in Appendix C.

This section presents the findings from DTZ’s survey of employers and selected ‘umbrella’ organisations. There were two main objectives.

1. To understand further the contribution of PhD education to employer performance, building upon the findings of the literature review.

2. To pilot the survey and learn lessons for Phase 2 to help develop a research method that is fit for purpose.

We have structured this section as follows.

- Research methodology
- Sample characteristics
- Research findings
- Wider issues
- Implications for Phase 2.
Given the importance of the employer consultations to the study, we have concentrated our efforts on the analysis and presentation of these results. Where appropriate, we have supplemented this with the findings from the umbrella organisations. It is also important to note that there was a high level of correlation in views expressed between the two cohorts.

3.2 Research methodology

The objective was to undertake telephone interviews with a sample of:

- 20–25 employers of PhDs to pilot the survey for Phase 2; and
- 20–25 umbrella organisations, defined as bodies that would be able to provide a view on the contribution of PhD education to employers. These included Research Councils, Sector Skills Councils and employer representative bodies.

Sampling – given the small numbers involved, there was no attempt to draw a statistically robust sample. Instead, EPSRC and BIS forwarded contacts that they thought would be able to provide an informed opinion. DTZ supplemented this with their own contacts, often derived from consultees making further recommendations on ‘opinion-formers’.

Questionnaire – a semi-structured questionnaire was developed, with Section 3 focused on employers and Section 4 on umbrella organisations (see Appendix C).

Interviewing – all of the interviews were conducted in-house by a three person DTZ team. The level of engagement ranged from five minutes to one hour or more. This extreme variation was due directly to:

- The nature of the consultee – those from HR/media did not have the required background knowledge to provide in-depth feedback. In contrast, the level of engagement was very high for those interviewees with a PhD and for whom doctoral education was critical for their business.

- The nature of the organisation – those organisations that had a research focus tended to be very engaged with the interview, whereas engagement was low in those in industries where there was no requirement for PhD trained staff.

Achieved sample - DTZ did not manage to reach its target sample size of 20–25 for each of the cohorts targeted. This was disappointing given the relatively generously drawn list of organisations. This reflected a number of factors.

- Difficulty of getting a response – there were only three to four outright refusals to participate per cohort. This may reflect the fact that the target interviewees are operating in an ‘information overload’ environment and find it difficult to make the time for a consultation. It should also be noted that the level of effort was high in terms of trying to secure an interview, where the following steps were taken.
  - EPSRC/RCUK letter
  - E-mail follow-up
  - Telephone follow-up, with at least two calls per organisation.
• *Imprecise targeting* – this could be at both organisation and consultee level. The latter, in particular, was a problem. There were incorrect contact details provided (e.g. telephone number not obtainable); the wrong person specified; the consultee having since left the organisation; etc.

There are important lessons for the methodology, which are discussed in more detail in Section 5.

**Table 3.1 Achieved sample**

<table>
<thead>
<tr>
<th>Survey</th>
<th>No. of Interviews</th>
<th>Response rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Completed</td>
<td>No Response</td>
</tr>
<tr>
<td>Employers</td>
<td>19</td>
<td>26</td>
</tr>
<tr>
<td>Umbrella organisations</td>
<td>15</td>
<td>14</td>
</tr>
</tbody>
</table>

Source: DTZ

### 3.3 Sample characteristics

#### 3.3.1 Employer organisations

Table 3.2 summarises the 19 organisations interviewed. The key classification data are discussed below, as this information may have an important bearing on the sampling and research method in Phase 2.
### Table 3.2 Company consultations - summary classification information

<table>
<thead>
<tr>
<th>Company Name</th>
<th>Consultee Position</th>
<th>Sector</th>
<th>Parent Nationality</th>
<th>No. Staff Worldwide</th>
<th>No. PhDs UK</th>
<th>Research Function</th>
<th>Depth of Interview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cresset Biomolecular Discovery</td>
<td>CEO</td>
<td>Pharma/biotech – niche software</td>
<td>England</td>
<td>8</td>
<td>7</td>
<td>Yes</td>
<td>Medium</td>
</tr>
<tr>
<td>Eli Lilly and Company</td>
<td>HR Recruitment</td>
<td>Pharma</td>
<td>USA</td>
<td>40,400</td>
<td>31*</td>
<td>Yes</td>
<td>Medium</td>
</tr>
<tr>
<td>Wellahead Engineering Ltd</td>
<td>Management</td>
<td>Oil &amp; gas engineering</td>
<td>Scotland</td>
<td>Small</td>
<td>0</td>
<td>No</td>
<td>Light</td>
</tr>
<tr>
<td>Microsoft UK</td>
<td>Management</td>
<td>Software/computing</td>
<td>USA</td>
<td>88,200</td>
<td>25</td>
<td>Yes</td>
<td>Deep</td>
</tr>
<tr>
<td>Scottish &amp; Southern Energy</td>
<td>HR</td>
<td>Electricity generation</td>
<td>Scotland</td>
<td>Small no.</td>
<td>No</td>
<td>Light</td>
<td></td>
</tr>
<tr>
<td>National Physical Laboratory</td>
<td>Management</td>
<td>Research centre</td>
<td>England</td>
<td>Large</td>
<td>&gt;22</td>
<td>Yes</td>
<td>Medium</td>
</tr>
<tr>
<td>Siemens AG</td>
<td>HR</td>
<td>Heavy engineering</td>
<td>Germany</td>
<td>420,800</td>
<td>Many</td>
<td>Yes</td>
<td>Light</td>
</tr>
<tr>
<td>Honeywell</td>
<td>HR</td>
<td>Engineering</td>
<td>USA</td>
<td>128,000</td>
<td>d/k</td>
<td>Yes</td>
<td>Light</td>
</tr>
<tr>
<td>Morgan Est plc</td>
<td>Media team</td>
<td>Construction</td>
<td>England</td>
<td>&gt;4,000</td>
<td>d/k few</td>
<td>No</td>
<td>Light</td>
</tr>
<tr>
<td>Innovspec inc.</td>
<td>Management</td>
<td>Chemicals</td>
<td>USA</td>
<td>1,000</td>
<td>D/K &gt;10?</td>
<td>Yes</td>
<td>Medium</td>
</tr>
<tr>
<td>Rolls Royce</td>
<td>Management</td>
<td>Aerospace/advanced engineering</td>
<td>UK</td>
<td>38,500</td>
<td>&gt;50?</td>
<td>Yes</td>
<td>Deep</td>
</tr>
<tr>
<td>National Grid</td>
<td>Management</td>
<td>Electricity/gas transmission &amp; distribution</td>
<td>England</td>
<td>27,000</td>
<td>100</td>
<td>No</td>
<td>Deep</td>
</tr>
<tr>
<td>Corus</td>
<td>Management</td>
<td>Metal manufacturing</td>
<td>India</td>
<td>37,000</td>
<td>&gt;50?</td>
<td>Yes</td>
<td>Medium</td>
</tr>
<tr>
<td>Croda Chemicals Europe Ltd</td>
<td>Management</td>
<td>Chemicals</td>
<td>England</td>
<td>3,500</td>
<td>d/k</td>
<td>Yes</td>
<td>Deep</td>
</tr>
<tr>
<td>Doosan Babcock Energy</td>
<td>Management</td>
<td>Engineering</td>
<td>England</td>
<td>5,000</td>
<td>40</td>
<td>Yes</td>
<td>Deep</td>
</tr>
<tr>
<td>BAE Systems</td>
<td>Management</td>
<td>Defence, security and aerospace</td>
<td>England</td>
<td>107,000</td>
<td>60</td>
<td>Yes</td>
<td>Medium</td>
</tr>
<tr>
<td>Pfizer</td>
<td>Management</td>
<td>Parma</td>
<td>USA</td>
<td>80,000</td>
<td>50**</td>
<td>Yes</td>
<td>Deep</td>
</tr>
<tr>
<td>Scottish Water</td>
<td>Management</td>
<td>Water /utilities</td>
<td>Scotland</td>
<td>3,700</td>
<td>?</td>
<td>No</td>
<td>Light</td>
</tr>
<tr>
<td>Unilever</td>
<td>Management</td>
<td>FMCG</td>
<td>UK/USA</td>
<td>163,000</td>
<td>?</td>
<td>Yes</td>
<td>Medium</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>&gt;445</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: * No. of PhDs Worldwide, ** One UK research dept only
Source: DTZ
Sector - there was good representation across a number of the key UK industries (see Table 3.3). All of the organisations were from the private sector with the exception of Scottish Water. The National Physical Laboratory is privately run by NPL Management Ltd on behalf of the National Measurement Office. The other key feature is that there was no representation from the services sector, including financial services, nor creative industries.

Table 3.3 Sectoral Classification of Employers

<table>
<thead>
<tr>
<th>Sector</th>
<th>No. of Interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Advanced engineering</td>
<td>4</td>
</tr>
<tr>
<td>Pharmaceuticals</td>
<td>3</td>
</tr>
<tr>
<td>Energy</td>
<td>3</td>
</tr>
<tr>
<td>Chemicals</td>
<td>2</td>
</tr>
<tr>
<td>Heavy engineering</td>
<td>1</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>1</td>
</tr>
<tr>
<td>Utilities</td>
<td>1</td>
</tr>
<tr>
<td>FMCG</td>
<td>1</td>
</tr>
<tr>
<td>Research Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>Software/IT</td>
<td>1</td>
</tr>
<tr>
<td>Construction</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>19</td>
</tr>
</tbody>
</table>

Source: DTZ

Parent nationality – a high proportion of the sample was drawn from businesses owned outside the UK: 8 organisations, or 42%, were foreign controlled.

Employer size – only two organisations could be classified as SMEs. The rest were large, employing over 1,000 staff. Of these, 13 were major multinationals in world terms. There was therefore a heavy bias towards selecting the ‘big names’ on the knowledge/expectation that the uptake of PhD trained staff would be high.

PhD profile – it was difficult to get accurate information to profile PhD holders in the organisations. This reflects the fact that we were interviewing one person in what were often very large and complex organisations and, while they could talk knowledgeably about their own area, they did not necessarily know the wider business operations in the UK and overseas. The numbers varied from 0 to over 100.

Research focus – the final key classification field was research. There was a clear bias in the sample towards the selection of employers that had a defined research function, which reflects the strong correlation between research and demand for PhD trained staff. 14 out of the 19 employers had a research function.

As alluded to earlier, the quality of the interviews was heavily influenced by two key factors.

- Research focus – if the organisation was not engaged in research then the interview tended to have limited relevance for them and it generated no significant value to the study.
Consultee profile – if representatives from HR/media were interviewed then they did not have the information or knowledge required to answer the questions.

We classified the interviews as ‘deep’, ‘medium or ‘light’, which reflects the duration and quality of the consultation (see Figure 3.1). Of the 19 interviews, six were considered ‘light’ and they were all ‘non-research’ focused businesses and/or conducted with HR/media staff.

#### Figure 3.1 Depth of interviews (Numbers)

![Figure 3.1 Depth of interviews (Numbers)](image)

Source: DTZ

### 3.3.2 Umbrella organisations

Table 3.4 gives the structure of the sample for the umbrella bodies, with a mixture drawn from the Research Councils, Sector Skills Councils, employer and professional skills’ bodies.

#### Table 3.4 Classification of umbrella bodies

<table>
<thead>
<tr>
<th>Organisation type</th>
<th>Detail</th>
<th>No. of Interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Councils</td>
<td>RCUK Science &amp; Technology Facilities Council (STFC)</td>
<td>2</td>
</tr>
<tr>
<td>Sector Skills Councils</td>
<td>Skills for Health, SEMTA, Energy and Utility Skills</td>
<td>3</td>
</tr>
<tr>
<td>Employer and Skill Representative Bodies</td>
<td>UK Commission for Employment &amp; Skills (UKCES), Engineering, Pharmaceuticals, Chemicals, Medicine, Energy and Utility Skills</td>
<td>10</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>15</strong></td>
</tr>
</tbody>
</table>

Source: DTZ

In a similar fashion to the employer organisations, the quality of the interview was directly related to the importance of doctoral education to the organisation or sector. In some ways, the views were even more polarised than for employers, as the representative bodies, in particular, tended to have a strong representational role. For some, such as chemicals and
3.4 Research findings

To give a structure to the analysis, we have presented the information from the perspective of employers and based on a ‘PhD lifecycle’ – from the recruitment process at the start to the impact of PhD trained staff at the end (see Figure 3.2), although it is 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. Additional qualitative feedback from employers and umbrella organisations is presented in Appendices E and F covering the demand and supply side perspectives respectively.

Figure 3.2 Analytical framework for employers' survey

3.4.1 Recruitment

**Number of PhDs** – 18 out of the 19 employers have PhD qualified staff in their employment. Only one SME, which did not have a research focus, did not employ any post doctorates. However, it was often very difficult for the interviewees to specify with any accuracy the number of staff with a PhD qualification: ten employers found it difficult to even give an approximate figure. The numbers that were quoted ranged from a handful to over 100 for UK employees. This reflects the nature of the research carried out in Phase 1: a properly targeted questionnaire or a depth case study may allow for this information to be acquired, or at least a range in which the numbers fall.
Recruitment process - 14 employers had an ‘active’ recruitment policy, by which we mean that they actively went out into the market to recruit PhD graduates. This contrasted with the ‘passive’ recruitment policy of four employers, which assessed PhD applicants alongside any other applications to their business, be this from the graduate pool or for more experienced positions (see Figure 3.3). As discussed later in this section, the ‘active’ recruiters recognise the contribution and impact of PhD graduates to their business and this drives their recruitment policy. Indeed, for most of them, PhD calibre staff are the ‘lifeblood’ of their organisation and their contribution to research, innovation and development is crucial.

Figure 3.3 Active and formalised recruitment

Of the active recruiters, eight had formalised recruitment policies bespoke to PhD recruitment. These tended to be either doctoral sponsorships or post doctoral fellowship programmes. In general, the formal mechanisms did not tend to have a strong follow through in terms of subsequent recruitment to the organisation. Sometimes, the proportion of filled places was as low as 10%. However, this was not considered to be a negative. For these larger employers, their corporate philosophy was one of investing in the individual with some returns to the organisation during the internship or postdoctoral programme, but also long term benefits to their industry and society.

From the umbrella organisations’ perspective, there were a range of conflicting factors believed to be impacting on employers 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 companies such as GSK, Pfizer and the big 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. As a result, non-PhD holders are getting employed less and less by the pharmaceutical industry”. This view was corroborated by employer consultations.

- **Over-qualification** – A number of umbrella organisations stated their concern over the trend towards the recruitment of over-qualified staff. This stems from the perceived dilution of the UK labour market with the large increase in graduates in the last decade, combined with the recent global downturn. Employees are having to differentiate themselves through post-graduate qualifications and employers are responding by focusing on those with post-graduate qualifications, particularly Masters, but also including PhDs.

“There is some degree of over qualification, for example you can do a post grad in discipline ‘x’, but it does not add a huge amount – in our sector the skills can be learnt on the job. So why would you need to do it?

*Our public sector employer has introduced an artificial ranking system which sets posts at inappropriate qualification levels. There is a poor link between what employers want and the recruitment process."

- **Sectoral demand** - recruitment of PhDs is crucial for a number of sectors including pharmaceuticals/biotech, energy, petrochemicals and biological raw materials. Engineering ‘intensity’ is accelerating for these sectors, which is defined as the rate of change in technology and its complexity. The upsurge in renewables technology is a good example in the power sector. It is less so for engineering contracting, where an M.Eng degree is the optimal qualification for less research intensive sectors.

### 3.4.2 Competencies

In general, for those employers that are heavily dependent on PhD qualified staff, there was a widespread and very strong endorsement of their capabilities. This was very much a case of ‘preaching to the converted’ as the consultees were usually PhD qualified themselves and responsible for discrete research functions in their business. In contrast, those employers that were not dependent on recruiting PhDs tended to have a more negative view. The pros and cons of PhD graduate competencies are summarised in Table 3.5.
Table 3.5 PhD graduate competencies

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Technical know-how relevant to the employer’s sector</td>
<td>● Lack of customer facing skills</td>
</tr>
<tr>
<td>● Research and analytical skills</td>
<td>● Limited commercial experience (compared to a graduate who has been trained in-house for three years)</td>
</tr>
<tr>
<td>● Problem solving and innovation</td>
<td>● Weak interpersonal and communication skills</td>
</tr>
<tr>
<td>● Ability to think differently (‘outside the box’)</td>
<td>● Striving for perfection and lacking commercial judgement in balancing inputs to outputs</td>
</tr>
<tr>
<td>● Ability to work independently – self-management</td>
<td>● Ability to make decisions based on limited information.</td>
</tr>
<tr>
<td>● Leadership – PhD recruits often destined for Research Team Leader roles and beyond</td>
<td></td>
</tr>
<tr>
<td>● Confidence and maturity</td>
<td></td>
</tr>
<tr>
<td>● ‘Stickability’ – the ability to persevere</td>
<td></td>
</tr>
<tr>
<td>● More rounded individuals</td>
<td></td>
</tr>
<tr>
<td>● Practical experience gained during the doctoral programme</td>
<td></td>
</tr>
</tbody>
</table>

Source: DTZ

It is informative to link the assessment of competencies to the type of roles that PhD graduates perform. Given that our sample size was very small and biased towards research intensive functions, there are limits on what we can deduce. However, a broad pattern did emerge between two main role profiles for PhD graduates: those that are research intensive and those that are employed in other more generic functions. This is a very broad generalisation, especially for the ‘non-research roles’, and we will want to test this hypothesis through the more detailed research in Phase 2. The challenge will be to identify which functions other than technology/IT focused ‘research’ that PhD graduates excel in. For example, the Workshop and Steering Group meetings have made references to the important contribution of PhD graduates in the financial services sector and creative industries.
Table 3.6 Research intensive roles vs. non research intensive roles

<table>
<thead>
<tr>
<th>Description of role profile</th>
<th>Research intensive roles (‘proven’)</th>
<th>Non-research roles (hypotheses)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific, technology and IT focused research posts, typically working in a laboratory/creative design type setting. The outputs relate to new products and processes, design and IT solutions that are leading edge and critical for maintaining world class performance.</td>
<td>The employment of PhD graduates in functions that are not directly related to research and innovation. Such jobs are more akin to the type of roles that graduate programmes would address in terms management, finance, HR, marketing, etc.</td>
<td></td>
</tr>
</tbody>
</table>

Perceived characteristics of PhD graduates in performing these roles

- Research & analytical skills
- Problem solving and innovation
- Ability to work independently
- Ability to think differently
- Attention to detail
- Perseverance
- Lack of customer facing skills
- Limited commercial experience
- Weak interpersonal and skills
- Striving for perfection
- Lacking commercial judgement
- Inability to make decisions

Overall employer assessment

PhD graduates are ideally suited to these roles, indeed, in many cases there are no alternatives. The future success of these staff is critical to the future technology and innovation performance of the organisation. PhD graduates are often not suited to these roles, indeed, there can be significant downsides in terms of lack of commerciality and cost-effectiveness of the individuals concerned.

Source: DTZ

3.4.3 Remuneration

The majority of employers indicated that they pay a premium to recruit PhD staff. Ten employers pay a higher salary, seven similar and, for two, this information was not available (although we would expect from the nature of the organisation for a premium to be paid).

Figure 3.4 Remuneration of PhD Graduates (Number)

Source: DTZ
However, it was not always clear-cut as to the baseline they were using for this comparison. Some employers were comparing against the graduate intake and, intuitively, one would expect there to be grounds for a salary differential, given the additional investment in education and training. However, for others, they were comparing a PhD graduate against graduates who had completed their in-house graduate training scheme after three years of employment. Limited information was provided on the scale of the salary differentials. Anecdotal comments included:

**Higher paying employers**

- “We have to pay premium rates for the specialist skills we need.”
- “PhDs enter at a higher grade in the company, so their remuneration is higher.”
- “Most enter at the ‘Higher Research Scientist’ level.”
- “We pay a salary increment for PhD recruits.”
- “10% higher pay than graduates.”
- “Salary can be higher depending on the individual’s publication records, patents, conference publications, etc. This can increase their grading and hence remuneration in the company.”
- “There can be an £8–10k differential in pay a few years down the line – PhDs versus graduates.”

**Similar paying employers**

- “It is the best person for the job, irrespective of academic qualifications.”
- “Our PhD graduates are on the same salary as our graduates once they have been through the three year Graduate Training Scheme. Chartered Engineers can be paid more.”

As one would expect, those employers that do have a research function value the contribution of PhD graduates and are prepared to a premium, often quite a significant one. This reflects the market mechanism and the value which such employers place on the impact that PhD graduates can generate.

Vice-versa, those organisations that do not have a research function and do not prioritise PhD graduates in their recruitment strategy are the ones that tend not to pay a premium. Here, the PhD graduates are competing on a like-for-like basis with other graduates.

The umbrella organisations reinforced these findings as the following quotation demonstrates.

“If entering a research role, then a PhD holder will be valuable, but, if entering an operational post, PhD holders will not add a huge amount. Many salaries are only marginally higher for PhD holders (oil and gas sector, for example).”

### 3.4.4 Career progression

For research based employers actively recruiting PhDs, there was an almost unanimous agreement that the PhD qualification and associated experience was a ‘passport’ to more rapid and effective progression to Team Leader grade and beyond. 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 and do not prioritise PhD recruitment.

### 3.4.5 PhD training support

Only one of the employers consulted had a tailored training programme for PhD graduates joining the company (along similar lines to a graduate training programme). The key aspects from the employers’ perspective are:

• they expect to be recruiting fully ‘tooled up’ PhD graduates in the technical discipline(s) relevant to their business;
• the PhD graduates do have important development needs, particularly in the softer competencies, but these are picked up through the normal training and development provision within the employer; and
• the main focus is on-the-job training.

The only exceptions to the above are the investments that some employers make in supporting PhD education through:

• Post-doctoral Fellowship Programmes;
• PhD Scholarship Programmes; and
• PhD Internship Programmes.

However, these have no commitment to employment of the trainees and do not really address the training and development requirements of mainstream PhD recruits.

### 3.4.6 Satisfaction

For those employers that actively recruit PhD trained staff (14), the level of satisfaction with their PhD graduates was either ‘high’ or ‘very high’. There was no evidence that any employers were switching their emphasis away from PhD trained staff. This reflects the contribution and impact that PhD graduates can confer (see further evidence of this under the ‘Impact’ sub-section below).

However, throughout this research, the ‘PhD’ qualification has been used generically. There were important distinctions raised by both employers and umbrella bodies between the MEng, PhD and EngD. For research intensive industries, there was a strong endorsement of the EngD over the PhD (see Table 3.6). They identified the following strengths of the EngD programme.
• The longer duration of the programme – it is recognised that the UK PhD is of relatively short duration compared to equivalents in the US and Asia.
• The value that the industrial placement confers, which makes EngD graduates more ‘industry-ready’.
• The experience of working on a range of different projects, which gives breadth as well as depth.
• The value of taught course elements.

The feedback from this employer is illustrative.

“Through this experience, they (EngD graduates) can provide greater flexibility and bring more rounded skills to the job - this is what employers want. Essentially, while we do recruit PhD holders, we can get more out of an EngD holder. There is a higher percentage of EngD employees in the organisation because of this preference.”

Table 3.7 gives a broad generalisation from our research and is not in any way conclusive. However, it does indicate that for a number of the employers consulted, a clear demarcation was made between the degrees.

• For some employers, there was a preference to recruit MEng graduates over PhDs. However, it was recognised that, over time, the impact of a PhD holder would overtake that of an MEng.
• There was also a marked preference to recruit EngD graduates over PhDs. However, it was recognised that, over time, the impact of a PhD holder could possibly ‘catch-up’ with the EngD.

Table 3.7 Employer ranking of degrees*

<table>
<thead>
<tr>
<th></th>
<th>MEng</th>
<th>PhD</th>
<th>EngD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short Term (1–2 years)</td>
<td>2nd</td>
<td>3rd</td>
<td>1st</td>
</tr>
<tr>
<td>Medium Term (3–5 years)</td>
<td>3rd</td>
<td>2nd</td>
<td>1st</td>
</tr>
<tr>
<td>Long Term (5+ years)</td>
<td>3rd</td>
<td>1st</td>
<td>1st</td>
</tr>
</tbody>
</table>

Note: * Ranking is in terms of impact and contribution to the employer organisation

Source: DTZ

3.4.7 Impact

Transmission mechanism

A key focus of this research is to understand not just the nature and significance of impact from PhD graduates, 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. Furthermore, the pilot (Phase 1) survey of employers has been relatively narrow in terms of the number of type of employers consulted and the role profiles of the PhD graduates they employ. This has limited the scope of our analysis and what we have been able to distil from the pilot survey.

As explained in the competencies sub section (section 3.4.2), there is really only one broad classification of role profiles that our primary research in Phase 1 enables us to discuss with
any authority. This relates to what we have called ‘research intensive’ roles. Based on this definition and our research findings from the employer survey, we have developed an embryonic impact and transmission mechanism framework (see Figure 3.5).

The overall framework is based on a straightforward logic model, based on the original model in Figure 1.1, which links the inputs at one end of the spectrum to final impacts at the other end. 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.

The model is based on results of the qualitative interviews, particularly with the ‘research intensive’ organisations. The bullets provide examples (e.g. of PhD research roles), to illustrate what is meant, but are not intended to be comprehensive at this stage.
Figure 3.5 Impact framework and transmission mechanism for ‘research intensive’ employers

**Inputs**

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

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

**Transmission Mechanism**

**Role Profile & Activity**

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

**Outputs – Intermediate**

- **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

**Outputs - Final**

- **Open Innovation & Knowledge Exchange**

**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

**Indirect (partners)**

- Universities
- Institutes
- Business Partners
- Suppliers
- Customers
- Government

**Indirect Impact**

- Govt. policies
- Industry practices
- Environmental and societal benefits

Source: DTZ
Lessons learned

Our Phase 1 pilot survey has confirmed the following.

- **Research functions vs. non-research functions.** It is much easier for employers to identify and explain impact when PhD graduates are recruited for specific research functions with a scientific, technical or IT focus. Our expectation is that it will be difficult in the Phase 2 survey to identify PhD employers in non-research functions and for them to articulate the nature and contribution of the impact that PhD graduates generate for them. In particular, this will relate to functions that are related to ‘mainstream’ operational and management functions in finance, HR, marketing, logistics, etc.

- **Impact type vs. impact process.** It is much easier for employers to describe the nature of impacts that PhD graduates can generate rather than explain the transmission mechanism through which such impacts are generated. Research intensive employers know that PhD graduates are critical to their mission, but it often difficult to attribute impact, especially when such impacts can be 15 years ‘down the line’.

- **Direct vs. indirect impact.** It is much easier to try and explain the transmission mechanism for employers (even if it is difficult for them to attribute impact to PhDs in quantitative or measurable terms), than it is for wider indirect and spillover impacts on third parties. This is why we have colour coded the left hand side of the transmission mechanism in Figure 3.5 green and the right hand side red. We believe that the Phase 2 survey will struggle to articulate such impacts unless in-depth and detailed case studies are conducted with the full co-operation of the employers. The consultations would need to include PhD graduate employees, their managers, commercial and research partners, and possibly government and other public sector stakeholders.

Impacts recorded – employer perspective

Given the research focus in the employer sample, it is not surprising that the main areas of impact identified relate to innovation, new product development and the associated intellectual property, as well as the commercial benefits that flow from this activity (see Figure 3.5).

Out of the 19 employers, 16 either directly or indirectly attributed positive impacts through the employment of PhD graduates. Furthermore, those responding rated impact as either ‘high’ or ‘very high’. The survey generated a significant amount of qualitative evidence in support of the research and commercial impact for employers. However, there was more limited information on wider impacts. The main indirect impacts quoted related to benefits for other research bodies and universities through knowledge exchange and ‘open innovation’. There was very little discussion of wider spillover benefits relating to other partner companies, supply chains or government.
Impacts recorded – umbrella organisation perspective

Similar strong findings on impact were presented by the umbrella bodies. Some examples are quoted below. However, the view is that the impacts occur in companies of significant size in certain sectors where research is important.

“...but the skills that that one person can bring may be huge, for example they might think of an entirely new way to generate power....working on new ways to supply the electricity network, and this can have a huge impact.”

“It depends on the sector that they are working in. For sectors such as pharmaceuticals and aerospace, PhD students will bring about significant impacts in that they are leading research which is crucial to these sectors. For small companies, there is probably no awareness whatsoever of what kind of impacts PhDs can bring.”

However, as was highlighted at the Workshop, such organisations do not usually have direct involvement in recruiting PhDs for industry, therefore their views must be treated with some caution.
4. Conclusions and key findings from Phase 1

There are similarities between the key findings from the literature review and those from the primary research undertaken in Phase 1. These are summarised briefly below. The purpose of this section is to summarise the key findings, particularly those that could be triangulated from more than one source, from Sections 2 and 3.

- There seems to be general agreement over the strengths and weaknesses of PhD holders, but this tends to reflect the research intensity within an organisation. In research intensive organisations, PhD holders are seen as bringing quality into an organisation in terms of technical skills, innovative thinking, positive change and self-reliance. However, especially in non research intensive organisations, there were criticisms regarding the non conformist approach, degree of specialisation and lack of adaptability of PhD holders. In this regard, it is surprising that no specialist training is made for these graduates when they are recruited, e.g. in developing their commercial awareness and integration with other skill lines. Such skills may be most effectively developed in-house, within the respective organisations, rather than through formalised training programmes. In this way, they will be embedded within the organisation’s work practices and specific focus. In turn, this would strengthen the impacts generated.

- The EPSRC is aware of this issue from previous research and has put funding in place to address this, e.g. £1.4 million of funding put in place in 2007 and £2.4 million in 2008 to support training and course development in entrepreneurship, with the aim of increasing awareness and encouraging innovative approaches to the exploitation of research. The impact of this investment may not as yet be ‘coming through the system’ and organisations may be basing their views on PhDs who may not have benefited from this funding and training.

- Organisations seem to be aware of what the impacts of PhD holders are, at least within organisations themselves if not the wider economy or society. However, this awareness is restricted to certain types of companies in certain economic sectors. More work is required before we can better define typologies of impact and group types of companies against such impacts, but the impacts are particularly important in sectors dependent on R&D. Figure 3.5 is an attempt to do this based on the evidence collected in Phase 1. Certain roles appear to generate impact, e.g. scientific research, software development and advanced process engineering. Employers are seeking direct outputs from PhD holders such as enhanced innovation and new products/processes through the provision of technical skills, new thinking and problem solving abilities. Through Open Innovation and Knowledge Exchange, this can impact on their partners to create indirect impacts on, for example, government policy and industry practices/standards. This helps to achieve the wider impacts, especially in improved economic performance. The long-term nature of such outputs and impacts, however, can make it difficult for organisations to be precise about how, why and when they have occurred, especially for indirect and wider impacts.

60 http://www.rcuk.ac.uk/cmsweb/downloads/rcuk/researchcareers/08repsument.pdf
However, the literature indicates that there is a gap between demand for graduates in numerate subjects and the supply of these graduates, which is resulting in skills shortages in some sectors of the economy. Allied to this, there are concerns among employers about any weakening of the UK PhD, e.g. through a reduction in government funding, and the UK losing its competitive advantage in key economic sectors to other countries through lack of supply of science-based graduates in growing industries.

Despite recognising these impacts, companies do not appear to track recruits within their organisations or measure impacts in a way that is attributable to individuals or broad educational levels, which means that better ways need to be developed to better gather information on the impacts of PhD holders.

Those organisations that already employ PhD holders, or who have PhD holders embedded in the recruitment process, are also more likely to recruit more people with PhDs.

There appear to be a number of economic sectors/organisations that do not value or proactively recruit PhD holders. The question is whether this is because PhD holders cannot offer anything to these sectors/organisations, or whether there are lost opportunities for PhD holders, with consequences for these sectors/organisations and the economy itself. It seems that larger organisations are more likely to recruit, or set out to recruit, PhDs. Given the contribution of small and medium sized enterprise (SMEs) to the UK economy and employment opportunities, it seems important to develop a better understanding of the role PhDs might have in SMEs, whether as entrepreneurs or as key sources of innovation and competitiveness.
5. Implications and recommendations for Phase 2

Key findings

- Phase 2 of the research should focus on those organisations that actively recruit PhD holders or where PhD holders should make a contribution. Only these sectors/organisations are likely to know about the impact of PhD holders.
- The most relevant sectors to target appear to be Pharmaceuticals/Chemistry, Aerospace/Engineering, IT, and Business & Finance.
- A key part of Phase 2 will be an attempt to develop groupings of types of impact by types of organisations, particularly in the quantitative part of the study. However, it is likely that only qualitative research will provide the level of detail required to understand how and why impact is generated by PhD holders in organisations, as well as the indirect and wider impacts to which they contribute.
- This could be supplemented with sectoral focus groups, e.g. channelled through the umbrella bodies.
- The questions and topic guides for Phase 2 should be aimed at developing the logic model on impact, from inputs to overall impacts.

5.1 Implications for Phase 2

There are a number of implications for Phase 2 of the research based on the findings from the primary research in Phase 1. The key points are highlighted below.

5.1.1 Researching umbrella bodies

- The engagement of these bodies tended to be very much a ‘black and white’ outcome: either they were fully engaged and prepared to devote an hour to the interview, or they perceived PhD education as peripheral or not relevant to the objectives of their organisation.

- For those that were engaged, there was the offer from some to participate in Phase 2 via workshops or other communication channels. These tended to be the representatives of the high technology and research intensive industries.

5.1.2 Researching employers

- **Sectoral focus** – It is stating the obvious, but Phase 2 should try to target those sectors that are likely to be proactive recruiters of PhDs. The lessons from the employers’ survey are clear-cut: if they do not target PhDs, then little information of value will be generated. If there is latent demand for PhD graduates, then this is likely to be linked to specific sectors. The research in Phase 1 has revealed that employers can be classified into three broad groups.

  - ‘Engaged’ – those that are heavily dependent on PhD graduates, linked to R&D, where innovation is the lifeblood of the organisation. They recognise and value the contribution of PhD graduates.
o ‘Question-marks’ – those where PhDs could, in principle, make a more significant contribution, but where information failures may apply and uptake is lower than optimal.

o ‘Disengaged’ – those where the requirements of the sector are such that there is no requirement for PhD recruitment and this is a logical commercial decision.

It seems obvious that the focus of the remainder to the study should focus on the ‘engaged’ and not on the ‘disengaged’, as only the former of these two groups is likely to be able to assess impact. Our ‘blind spot’ relates to the ‘question-marks’. We need to learn more about which sectors are under-investing in PhD graduate recruitment, the reasons for this and what could be done to overcome this market failure.

- **Interviewee profile** – It is critical to interview a member of the management team who has responsibility for the research function (or the business activity that the PhD graduates are recruited into). Targeting HR or media representatives does not work.

- **Groupings/typologies** – It may be possible to list typologies of roles and impacts and group by types of organisation. The focus was on research intensive organisations and large companies in Phase 1. However, organisations could be classified using the CIHE descriptions in its recent study on Talent Fishing, described in Section 3. Our sample would have to widen considerably before an attempt could be undertaken to do this sort of exercise with any reliability.

- **Quantitative information** – Careful consideration needs to be given as to what quantitative information the study should attempt to obtain in Phase 2. There is a danger that a survey will provide little meaningful data at high cost. For this reason, the purpose of this part of the research must be focused on collecting data, which will be possible to collect, and produces analysis that will be usable and is not available from any other current source. The Workshop discussion indicated a desire to know more about the different types of impact, how they occurred in different types of organisations and why these organisations will looking to generate this type of impact, as discussed in the previous bullet. This may help to give this survey the focus that it needs. Another, related, suggestion was to form hypotheses based on analysis of secondary data sources on research intensive and innovative sectors of the UK and use the survey to test these. This is discussed later in this section.

- **Qualitative information** – Although quantitative data analysis may help this grouping exercise, it is unlikely to provide the level of detail and understanding required as to how and why impact is generated by PhD holders in individual organisations. This could only really be gained by case studies and more qualitative analysis.

### 5.2 Analysis of secondary sources

In order to inform Phase 2, the Workshop and the Steering Group meeting after it discussed using secondary data sources to help with targeting of particular companies/sectors as well as helping to form hypotheses to be tested in the next phase of the research. This was not intended to be an in-depth exercise, rather it was a short project to help to focus the study resources for Phase 2.
This sub section addresses a number of key questions raised. These questions are addressed through the use of a number of sources from BIS, NESTA, DTI, ONS and OECD, provided by Dr. Rosa Fernandez at BIS.

**Which are the most intensive R&D sectors in the UK?**
The Pharmaceuticals product group represents 27% of all BERD spending in the UK. Other significant sectors include Aerospace (11%), Computer & Related Activities (9%), Post & Telecommunications (9%) and Motor Vehicle & Parts (8%)\(^61\).

**Which are the most innovation active sectors in the UK?**
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\(^62\).

Innovative businesses are most prevalent in the following industries by broad SIC code\(^63\).

- 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%)\(^64\).

The percentage of innovation active large companies (60%) is only 2 percentage points higher than SMEs, but large companies are more likely to engage in most forms of innovation behaviour. More than 80% of BERD in the UK is accounted for by large firms (250 or more employees)\(^65\).

There are some rapidly emerging innovation active sectors. Across the OECD, patents in renewable energy and air pollution control increased more rapidly than any other patent groups in 1996-2006\(^66\), at 20% and 12% respectively against an increase for total patents of 11%.

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\(^{62}\) NESTA, *The Innovation Index – measuring the UK’s investment in innovation and its effects.* November 2009.


\(^{64}\) 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.

\(^{65}\) OECD, *op cit.*

\(^{66}\) OECD, *op cit.*
What is the contribution to the UK economy of such sectors?

Selecting a number of relevant key research and innovation sectors, we can estimate their contribution to the overall economy by using the latest Annual Business Inquiry (ABI) data for 2008 from the ONS to calculate their contribution to GVA at basic prices. The contribution of these sectors to the overall economy is relatively small, particularly those in manufacturing industry, which now only makes up around 10% of the total economy. They should therefore be seen as niche sectors. Business and financial services, however, has grown rapidly in the last decade.

Table 5.1 Contribution of relevant economic sectors to the overall economy

<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</td>
<td>44,317</td>
<td>2.4%</td>
</tr>
<tr>
<td>Business &amp; financial services</td>
<td>205,514</td>
<td>11.2%</td>
</tr>
<tr>
<td>Electricity, Gas &amp; Water</td>
<td>38,274</td>
<td>2.1%</td>
</tr>
</tbody>
</table>

Source: DTZ analysis of ONS data

Total BERD expenditure in the UK in 2008 was £15.9 billion, a 2% increase on 2007. This represents 1.1% of UK GDP. 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.

Around 152,000 FTEs are employed on R&D in UK businesses (2008). 86,000 of these are scientists and engineers, 38,000 are technicians, laboratory assistants and draughtsmen, and 28,000 are administrative, clerical, industrial and other staff.

The private sector invested £133 billion in innovation in the UK in 2007, about 14% of private sector GVA, and 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.

67 Defined as computer programming, consultancy and related services, and information service activities
68 ONS, op cit.
69 NESTA, op cit.
70 ONS, op cit.
71 NESTA, op cit.
Which economic sectors are most likely to employ PhD holders?
This question was addressed by Vitae and covered in Section 3: Education, Manufacturing, and Business, Finance & IT. To capture more data on this will probably involve direct contact with the ONS.

A recent paper by the DTI 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. 72

5.3 Phase 2 method

Appendix F provides an illustration of the original plan for the main stages in Phase 2 of the study. This needs to be revised in the light of Phase 1 of the research.

Extracting the lessons from Phase 1 as well as using the outcomes of the Workshop discussion and the further secondary data analysis, DTZ has developed a new approach to Phase 2.

In essence, the outline method remains the same, as do most of the stages. The key change to explore is around the volume of research with the companies.

It was apparent in Phase 1 that there are a number of companies, particularly those for which R&D is important, that actively target PhD holders. It is these companies that will be best placed to assess impact. It seems clear that these companies would be able to provide further details on their approach to employing PhD holders and in assessing their impact, and would be worthwhile participants in a volume survey as well as offering potential for more detailed case studies.

However, many of the companies with which we spoke do not target PhD holders in this way and having a PhD is merely one factor that they will consider in an applicant's CV. It is obvious from the Phase 1 research that these types of companies will not be able to provide much more relevant evidence and including them in another phase of the research is unlikely to be cost effective.

For this reason, we now believe that Phase 2 would benefit from a more targeted approach that aims at particular sectors of the economy (e.g. pharmaceuticals, aerospace) or companies with particular attributes, e.g. high R&D spend relative to turnover. It should,

however, still be the intention to sample companies of a range of sizes. This approach would not provide a definitive assessment of ‘impact’ across the UK corporate sector, but it will be valuable in providing more granular information about impact and how and where it occurs, as well as some of the key differences across sectors and company types.

5.3.1 Options for delivering Phase 2

It would seem that there are a number of possible approaches that could be undertaken in Phase 2, which are worthwhile exploring in this report, with a decision being made after full consideration of these options by the Steering Group. These options, as well as their advantages and disadvantages, are highlighted in Table 5.2.

Table 5.2 Possible options for primary research in Phase 2

<table>
<thead>
<tr>
<th>Option</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. 500 companies in 5-7 sectors, 10 minute interviews</td>
<td>Breadth of study, with ability to report reliably across a wide number of sectors</td>
<td>Insufficient depth of information and many organisations may have little to say</td>
</tr>
<tr>
<td>B. Lower number of interviews in 3-5 sectors (e.g. 300), but 15 minutes long</td>
<td>Greater depth and range of information, focused on organisations that are likely to be able to provide a greater level of detail</td>
<td>Not sufficiently representative; inability to cover all relevant sectors</td>
</tr>
<tr>
<td>C. Lower number of interviews (e.g. 200-300), but more case studies (e.g. 20-25)</td>
<td>Will provide a greater level of detail on specific organisations where impact is generated</td>
<td>Will reduce the breadth of information to be captured; lessons from individual organisations may not have wider applicability; costly to deliver</td>
</tr>
<tr>
<td>D. Lower number of interviews (e.g. 200-300), but some use of focus groups based on key economic sectors or company types (probably 3-4).</td>
<td>Will provide much greater depth of information</td>
<td>Not sufficiently representative; inability to cover all relevant sectors; employers may be less likely to divulge information in a meeting with their peers</td>
</tr>
</tbody>
</table>

Source: DTZ

These options are not mutually exclusive and a combination of two or more of them could be used. The current belief of the study team is that a more targeted approach is unlikely to require as many as 500 interviews. If, for example, the focus is on 3-4 intensive R&D sectors, with around 30-50 companies per sector, there would be 120-200 interviews in total. This would allow the opportunity to lengthen the questionnaire for these companies (say to 15 minutes) to extract a greater range of data. It would also allow the opportunity to increase the number of case studies, e.g. to around 20-25, to help the study to acquire the depth as well as breadth of information and data that it needs. It may be useful to undertake focus groups on these sectors, where more detailed information could be captured at the same time from numerous organisations and a ‘sector view’ can emerge. This part of the research could also
allow for preparation for the volume survey and case studies, e.g. by identifying organisations to sample, acquiring contact details and testing key questions. However, we will need to further discuss this with some of the umbrella bodies that suggested this in Phase 1 to test how feasible it would be.

The selected option(s) would also have to be costed against the current budget for the research.

5.3.2 Organisation of Phase 2

The current preferred approach is to undertake the volume survey by a mixture of a web based survey and a telephone survey. We believe that, in the first instance, a letter from EPSRC/RCUK should be attached to the survey questionnaire as an email attachment and be sent to the sample of organisations. This would provide the opportunity for organisations to consider their response and consult internally before responding.

A telephone survey could be offered to companies that would prefer to respond in this way, or for smaller organisations that would be less likely to require to consult across divisions.

Given some of the difficulties experienced in obtaining the cooperation of a number of the organisations in Phase 1, it was suggested at the Workshop that the study team and EPSRC need to emphasise the importance of the research and the opportunity for those participating to influence policy in this area.

The case studies would still be undertaken through a mixture of face-to-face interviews (and company visits) and telephone interviews, probably with a number of key personnel in each organisation. Much information was obtained by telephone interviewing in Phase 1.

A database of organisations will be developed by DTZ and the Steering Group, as well as stakeholders such as CIHE, to be passed on to Swift Research to conduct the volume survey. Given the level of non response in Phase 1, the sample of organisations should be at least double the intended number of respondents, i.e. a database of at least 1,000 organisations would be required if the target level of respondents was 500. Based on Phase 1, this is likely to be a real challenge and there will be a need for all parties to work closely together to source these contacts with accurate contact details and the right personnel.

5.3.3 Questions for Phase 2

A questionnaire will need to be drafted for the survey questionnaire in Phase 2. This will be critical in helping to fill the gap in the current secondary sources, literature and what was possible to collect in Phase 1. As indicated above, the sample in Phase 2 will be much wider than the narrow focus from Phase 1 and will need to select a wider range of companies, including SMEs. However, it must still be targeted at those that are engaged or dependent on PhD graduates, or on those organisations where we would expect PhD holders to make a significant contribution.

We believe that the key questions in Phase 2 should focus on the following issues. This is based on our revised logic model in Figure 3.5. Results from Phase 2 will help to refine and improve this model.
Inputs

- **Headline figures**, e.g. numbers of PhD holders in the organisation, number of PhDs funded, numbers of post doctoral fellowships/interns.

- **Recruitment and targeting of PhD holders.** At an early stage, it will be important to ascertain how important PhD holders are to an organisation. This could be used to categorise organisations.

- **Training of PhD holders.** Will help to assess how important are the creation of ‘positive impacts’ and mitigation of ‘negative impacts’, and how organisations seek to maximise benefits. Again, requires investment (inputs) from employers and, perhaps, stakeholders.

Role profile and activities

- **Background information**, e.g. location, sector and size of organisation. This will be helpful in later categorising organisations.

- **Extent to which research and innovation are important** in these organisations. This will also help with the grouping exercise.

Intermediate outputs

- **Competencies and skills of PhD holders.** This will be related to the impacts that are desired. These will be relevant (direct) to the employer and also to partners (indirect).

- **Impacts that are sought** from employing PhD holders. This will also help in creating a typology of impacts, which can be compared across different types of organisations.

- **How these impacts are generated.** This will help us to understand the transmission mechanisms more fully.

- **The other functional roles for PhD holders** where employers can identify impact and explain the transmission mechanism.

Final outputs

- **The extent to which such research impacts are generated in practice.** This will relate to the employer (direct) and the wider impacts to other stakeholders (indirect). Are there barriers to achieving these? If so, how do organisations seek to circumvent them? By what means do the direct impacts produce indirect impacts, e.g. Open Innovation, Knowledge Exchange?

- **Limitations of PhD trained staff.** This will be related to barriers and may provide data on ‘negative impacts’.
- **Career paths and progression of PhD holders** within organisations. Necessary to know in order to understand impacts on the wider organisation and other staff.

**Overall impacts**

- **Wider impacts of PhD holders.** This is likely to be less known, but some organisations may be able to point to examples of wider economic, environmental or societal impacts that PhD holders have achieved while employed by them.

- **Consequences of not being able to employ PhD holders.** This would give us some assessment of the counterfactual and help with the assessment of how critical PhD holders and the impacts that they produce are to different types of organisations as well as to the wider economy and society.

It would appear that a quantitative survey may be the best method to attempt to construct typologies of impact, their magnitude of importance and groupings of companies against impact types, particularly for direct impacts. Qualitative research, e.g. through case studies, is likely to be needed to supplement this data, particularly in providing a fuller understanding of the transmission mechanisms that generate the impacts in individual organisations, as well as indirect and wider impact types.

The questionnaire has still to be finalised with the Steering Group, but we believe that a 10-15 minute questionnaire around these issues should be able to be answered by the vast majority of participating companies.

### 5.3.4 Choice of sectors

There are a number of sectors that could be included in the study. Below, we have attempted to rank these sectors by order of importance to the study based on the results from Phase 1 and the analysis of new secondary sources.

- **Pharmaceuticals/Chemistry** – A large proportion of EPSRC doctorates go into this sector and R&D is critically important to it. Accounts for the largest proportion of BERD of any sector in the UK.

- **Aerospace/Engineering** – As above. Accounts for the second largest proportion of BERD of any sector in the UK.

- **IT** – A high growth sector where innovation and creativity is important. Accounts for 9% of all BERD spending in the UK.

- **Business and financial services** - Even though these companies were not surveyed as part of Phase 1, the literature review does indicate that many EPSRC PhDs are going into these sectors. This may have been affected by the recent economic recession that had a major impact on this industry. Innovation and numeracy are key factor in services such as real estate, renting and business activities. The Workshop also believed that many EPSRC PhDs were going into this sector and this matter was little researched.
• **Renewables** – A growing sector with a heavy R&D focus. Has strong government support to grow. Rapid rise in patents in the OECD in this sector, emphasising the importance of innovation to it.

• **Electricity, Gas & Water/Energy** – A key economic sector with active PhD recruitment.

• **Public sector** – A significant proportion of PhD graduates go into this sector and there will be important differences with the private sector in terms of the competencies desired as well as impacts that are sought.

• **Life sciences** – Another high growth sector that is research-led.

• **Creative industries** – Small but possibly could achieve high levels of growth in the future and innovation led.
APPENDICES
### Appendix A – Bibliography for literature review

<table>
<thead>
<tr>
<th>Source of Literature</th>
<th>Focus of Literature</th>
<th>Inclusion criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What Do PhDs Do? – Trends provide insights into the first destinations of PhD graduates, commenting on the 2004-2006 surveys, UK GRAD Programme, Careers Research and Advisory Centre, 2007.</strong></td>
<td>Destinations, career paths, sectors of employment.</td>
<td></td>
</tr>
<tr>
<td><strong>SET for success: the supply of people with science, technology, engineering and mathematics skills, The Report of Sir Gareth Roberts’ Review, 2002.</strong></td>
<td>The supply of science and engineering skills in the UK and the difficulties employers face in recruiting highly skilled scientists and engineers.</td>
<td>✓</td>
</tr>
<tr>
<td><strong>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.</strong></td>
<td>Sets out a series of recommendations on how the Research Councils can increase economic impact.</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Leitch Review of Skills, Prosperity for all in the global economy, world class skills, 2006.</strong></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>
</tr>
<tr>
<td><strong>A Study of the Career Paths of PPARC PhD Students, DTZ, 2003.</strong></td>
<td>A longitudinal study of PhD students.</td>
<td>✓</td>
</tr>
<tr>
<td><strong>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.</strong></td>
<td>Information on how to assess career path information, highlighting lack of information on impact.</td>
<td>✓</td>
</tr>
<tr>
<td><strong>What do researchers do? Vitae, 2009</strong></td>
<td>First destinations of doctoral graduates by subject and career profiles of doctoral graduates.</td>
<td>✓</td>
</tr>
<tr>
<td>Title</td>
<td>Summary</td>
<td>√</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
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</tr>
<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>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>Study</td>
<td>Description</td>
<td>Status</td>
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<td>----------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
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<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>Manathunga, Catherine, Pitt, Rachael and Critchley, Christa (2009) ‘Graduate attribute development and employment outcomes: tracking PhD graduates’, 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>Talent Fishing – What Businesses Want from Postgraduates, 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 organising as well as a number of smaller organisations.</td>
<td>✓</td>
</tr>
</tbody>
</table>
Appendix B – Organisations consulted in Phase 1

Organisations

BAE Systems
Biomolecular Discovery
Corus
Croda
Doosan Babcock Energy
Eli Lilly
Honeywell
Innospec
Microsoft
Morgan Est
National Grid
National Physical Laboratory
Pfizer
Rolls Royce
Scottish & Southern Energy
Scottish Water
Siemens
Unilever
Wellahead Engineering Ltd.

Umbrella bodies

Association of British Healthcare Industries
Association of British Pharmaceutical Industry
Chartered Institution of Water & Environmental Management
Energy & Utility Skills
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
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 on the value 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, the 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

73 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 type 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 E.7 Global market context**

<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**\(^{74}\)
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**\(^{75}\)
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\(^{76}\).

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.

\(^{74}\) Based on information from: [http://www.sheffield.ac.uk/systemsutc/](http://www.sheffield.ac.uk/systemsutc/)

\(^{75}\) Based on information from: [http://www.eeesta.org.uk/index.php](http://www.eeesta.org.uk/index.php)

\(^{76}\) [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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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 Original plan for Phase 2 method

Key stages in Phase 2 of study

1. Inception & Mobilisation
2. Survey of Organisations
3. Analysis of Responses
4. Detailed Case Studies
5. Reporting & Presentation

Stage 1: Inception and mobilisation

This Phase was to start in much the same way as Phase 1, with a detailed inception meeting to discuss the objectives, refinement of method, etc. It will be particularly important to discuss the scale and range of the employers’ survey and how the results from this can be used, as well as agreeing on the lessons learned from Phase 1 to ensure that Phase 2 provides the client with the type of results/evidence that it requires.

Stage 2: Survey of organisations

Given the number of current doctoral students support at any one time by UK Research Councils (around 19,000), it is clear that these students will enter a wide range of employers when they graduate and, therefore, there is likely to be a wide range of impacts across a large number of organisations and sectors. The focus will be on those entering non-academic employment, therefore we proposed a wide-ranging survey of organisations across the UK to identify those that target PhD graduates as well as assess the impact that these graduates are having on their organisations.

The questionnaire for the survey was to be designed by DTZ in conjunction with the Steering Group and Swift Research. Swift Research Ltd. was to be responsible for the conduct of the survey and DTZ for analysis of it.
We assumed the questionnaire would include 30-40 questions, including 8 open-ended questions. We further assumed that the survey could be conducted in 10 minutes. This was to be a mixture of a web based survey and a telephone survey. Other methods were considered; for example, 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 believe a well structured telephone/web based survey is capable of eliciting as much information as a face-to-face survey. Our case study approach also allows us to probe and clarify particularly interesting responses. We planned to survey 500 organisations.

Stage 3: Analysis of responses

We planned to analyse the survey results to address the key questions identified above. Data tables of the results would be produced so that analysis of the data can take place. Cross-tabulations would be run by factors such as industry sector, location and subject specialism. Further analysis would then be considered in conjunction with the Steering Group.

Stage 4: Detailed case studies

We planned to use the survey evidence to identify organisations and sectors of interest in which PhD students/graduates are making significant impacts, or whose responses warrant further attention, for example organisations that believe that doctoral programmes are not developing graduates with the skills that they need. More focused probing and clarifying of responses would produce detailed case studies and would try to draw-out where and how impact occurs in a structured way, informed by all of the previous research undertaken in the study.

We planned to undertake around 15 of these detailed case studies in the Phase 2 programme.

Stage 5: Reporting

We would then produce a comprehensive draft report based on the evidence gathered for Phases 1 and 2 of the research, including a detailed write-up of all of the case studies.