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COLLABORATIVE DOCTORAL EDUCATION

UNIVERSITY-INDUSTRY PARTNERSHIPS FOR ENHANCING KNOWLEDGE EXCHANGE

DOC-CAREERS PROJECT
BY LIDIA BORRELL-DAMIAN

EUA
European University Association

SIXTH FRAMEWORK PROGRAMME

European Research Area

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List of tables and figures

Figures

Tables

Table of Contents

Foreword

Professor Jean-Marc Rapp
EUA President

Europe's universities are increasingly developing partnerships in their research and innovation missions and embracing the "open innovation model" of university/business cooperation. They are also seeking to embed this in sound project management and improved intellectual property management reflecting respective interests. In support of this, the European University Association has been working actively to achieve a sound dialogue with the main actors, public and private, research funding bodies and industry partners to improve the research environment and grant/contract conditions to enhance the contribution of Europe's universities, as strong and autonomous research institutions, to the creation of a globally competitive European Research Area.

An important aspect of EUA's activities in forwarding these goals has been its extensive work on doctoral education through gathering empirical evidence on the rapid development of doctoral programmes and schools seeking to offer greater critical mass, enhanced supervision and widened employment opportunities for doctorate holders in both public and private sectors. The core messages of EUA's work are that doctoral education is the bridge linking the European Higher Education Area and the European Research Area, and that, as the first stage of a research career, excellent conditions for doctoral level work will be crucial in determining the attractiveness of the choice of staying in and coming to Europe.

In this context, the "DOC-CAREERS" project places a timely focus on the development and characteristics of collaborative doctoral programmes established between universities and industry, whether government, university or industry-led. It examines the perspectives, expectations and experiences of the partners from university and industry and, not least, the doctoral candidates themselves. With over 50% of doctorate holders in Europe moving into careers beyond the academic sector, the importance of such collaborative programmes is evident. The value of the promotion and dissemination of good practices in such collaborative doctoral programmes, in particular on the inter-sectoral mobility achieved, the transferable skill components developed and the wider employment horizons opened, cannot be over-estimated in strengthening universities' innovative capacity.

Indeed, to borrow the language of the current policy debate, collaborative doctoral programmes can be seen as working models of the "knowledge triangle" whereby education, research and innovation are brought together in a common framework of high skills and knowledge development by university and industry partners. In its recent "Prague Declaration 2009", EUA has identified "10 Success Factors for European Universities in the Next Decade" – one of these being universities' abilities in developing partnerships to help strengthen their missions in teaching, research and innovation activities. In identifying and analysing the main trends and features of good practices in collaborative doctoral programmes, the "DOC-CAREERS" project offers encouragement to Europe's universities on ways and means to meet this "success factor".

For its part, EUA will take this work forward through further dissemination activities and in the context of the work programme of the new EUA Council for Doctoral Education (CDE).

Jean-Marc Rapp
EUA President

Acknowledgements

EUA is deeply grateful to the many persons in universities, companies and other organisations who agreed to participate in the DOC-CAREERS project and provided clear and frank views on their experiences in university-industry cooperation. Their informed contributions have allowed us to reflect accurately the values, opportunities and challenges of university-industry dialogue in doctoral education and the widened prospects of employment offered to doctorate holders in Europe.

We are indebted particularly to:

- Members of the Steering Committee who provided their guidance and insights throughout the project,
- University academic and administrative staff who responded enthusiastically to questionnaires and contributed to the workshops,
- Company CEOs who agreed to be interviewed by telephone or personal visits and those who, in addition, participated in the workshops, thus contributing to high-level and lively dialogues between academia and business,
- Members of the working group on institutional tracking methodologies of doctorate holders,
- Companies Siemens (Munich-Perlach) and Schlumberger (Paris-Clamart) for hosting workshops.

For their special commitment to the project, we would like to thank the following individuals:

- Andrew Dearing, Secretary General of EIRMA, the European Industrial Research Management Association, for his enthusiasm and unconditional support to the project from its beginning. He facilitated access to EIRMA membership and provided valuable input from the business point of view on collaborative doctoral education,
- Edwige Chassagneux, EIRMA, CIFRE doctorate candidate, who worked on the questionnaire for companies, conducted part of the interviews and preliminary analysis,
- Janet Metcalfe, Chair and Head of Vitae (UK), for chairing the working group on institutional tracking methodologies of doctorate holders, developing the questionnaire and analysing the outcomes,
- Maj-Britt Hedvall, Director of the Hanken Swedish School of Economics and Business Administration (Finland), for coordinating consultation with EDAMBA members, the Network of European Doctoral Programmes in Business Administration,
- Gemma Jackson, EUA Executive Assistant, for her high quality administrative and organisational support throughout the project.

At the heart of the "DOC-CAREERS" project, as its coordinator and author of this report, Lidia Borrell-Damian, EUA Senior Programme Manager, has had the principal responsibility for working with all the partners, analysing the evidence and bringing forward its results and recommendations. She has worked in a thorough and dedicated manner to ensure the success of the project as a truly collaborative research effort.

Finally, we would like to acknowledge the financial support of the European Commission – Directorate-General for Research – through a Specific Support Action within the FP6 action on 'Human Resources and Mobility Structuring the European Research Area'.

John H Smith
EUA Deputy Secretary-General

EUA acknowledges valuable contributions of EIRMA and Vitae to the project.

Executive Summary

Doctoral studies are among the most advanced and specialised forms of education and training available in modern societies. Their purpose can be defined in terms of providing society with the capacity for carrying out high quality research, and of producing highly-qualified graduates with options to engage in their chosen careers with the skills acquired during education and training through research. In both respects, societal and individual requirements are changing. Collaborative doctoral education is of growing importance in Europe given the increased focus on innovation through R&D in order to advance towards a more "knowledge-based" economy and the reality that a majority of doctorate graduates are destined for careers outside academia in both research and non-research positions. Today transdisciplinarity is also recognised to be essential for innovation and universities are unique environments where high academic standards and a vast range of disciplines meet and flourish, and R&D oriented business are becoming more aware of its potential.

The European University Association (EUA) in this report, *"Collaborative Doctoral Education: University-Industry Partnerships for Enhancing Knowledge Exchange"* presents the findings of the project "DOC-CAREERS: From Innovative Doctoral Education to Enhanced Career Opportunities", which was conducted with the financial support from the European Commission – Directorate-General for Research. The report draws upon also upon the knowledge and experience accumulated by EUA on doctoral programme reform through several projects in the framework of the "Third Cycle" of the Bologna Process, and on university-industry cooperation through the "Responsible Partnering Guidelines" initiative. The European Industrial Research Management Association (EIRMA), as one of the partners of the latter initiative, has been also a key partner in the conduct of this present study by facilitating the consultation with the business sector.

Set in the context of the current European research and higher education policy debate, and its emphasis on the need for more creative partnerships to foster innovation, the "DOC-CAREERS" project established a major dialogue with the main stakeholders with experience of collaborative doctoral programmes and doctorate holders' careers. A total of 82 organisations from more than 20 European countries and different sectors contributed to the project: 33 universities, 31 companies and 18 other stakeholders including university and professional networks, government bodies, university-industry interface organisations and other higher education organisations. Three distinctive areas were selected for special study: Science, Engineering and Technology (SET), Biotechnology, Medical and Life Sciences (BML), Economics and Social Sciences (ESS).

The DOC-CAREERS project examined a range of doctoral projects and programmes named "Collaborative Doctoral Projects", or "Programmes", respectively, involving interaction between a university, a doctoral candidate and a company. A distinctive characteristic of these is that industry experts take part in the supervisory committee, either officially or informally, and this is what distinguishes the cooperation from other types of collaborative contract research. Indeed, this role of industry is officially recognised and encouraged in some of the initiatives which have existed for some time such as the CIFRE, CASE and Danish Industrial PhD Programmes and Marie Curie Actions.

The analyses and findings are put forward to encourage discussion of the different approaches to collaborative doctoral education (and to doctoral education in general) and to highlight good practices, the common problems and some solutions towards solving them. Specifically, the report addresses: i) the objectives and conditions for the setting-up of collaborative doctoral programmes, ii) the motivations, benefits and challenges of the three partners – university, industry and doctoral candidate; iii) the main characteristics of collaborative doctoral programmes; iv) the unique position of the doctoral candidate as a link between university and industry, and recruitment

procedures operated; v) recommendations from stakeholders to other stakeholders; and vi) the impact of these types of programmes as measured and perceived by stakeholders.

Particular attention is given to employability perspectives of doctorate holders outside academia and its relationship to mobility, both inter-sectoral (between academia and industry) and intra-sectoral (within academia or within industry), and to their acquired skills, including those described as transferable skills. The study takes account also of methodologies that universities are using to track doctorate holder careers and how such tracking can be beneficial to institutional development and profiling of the institution.

The main conclusions and recommendations can be summarised as follows:

General remarks

Clear common patterns emerged concerning the setting up of collaborative doctoral projects/programmes and issues related to the skills of doctorate holders valued in academic and non-academic doctoral careers. The evidence provided by the case studies submitted within DOC-CAREERS demonstrates that, despite the frequency with which some concerns are expressed, the concerns can all be overcome in an efficient manner with appropriate management processes and attitudes by all parties.

Dialogue between university and industry on collaborative research is reaching a level of maturity that provides opportunities for effective action to promote durable relations between the academic and business worlds. There are distinctive European ways of responding to university-industry collaboration challenges which need further development and may offer a different approach to that practiced in North America and other regions of the world.

At the policy dialogue level several important European initiatives are already developing to respond to the challenges. These include the European Commission Communication on "Better Careers and More Mobility: a European Partnership for Researchers", Marie Curie Actions, the European Commission Recommendation "on the Management of Intellectual Property in Knowledge Transfer Activities and Code of Practice for Universities and Other Public Research Organisations", the Responsible Partnering Guidelines and the EUA Council for Doctoral Education (EUA-CDE). DOC-CAREERS outcomes will feed into the policy dialogue and they are the basis for further work by EUA and other interested organisations.

Employability and Mobility of Doctorate Holders

The DOC-CAREERS case studies support the general statement that 50% of current doctoral holders are employed outside academia, in businesses, governments, service sector and other education sectors, holding both research and non-research positions. Career paths of doctorate holders are extremely diverse, hence it is very difficult to talk about typologies of doctoral careers and it is more appropriate to talk broadly about the career or employment opportunities that are open to people who have been highly trained in the methods of research.

In addition to the skills naturally acquired through research, there is a group of competencies common to all fields that are likely to make a doctorate holder more employable outside an academic context. Some of them relate to communication, negotiation and management skills. However, potential employers may be less aware of other skills acquired during the doctoral process, such as adaptability, the capacity to deal with complex problems and to engage in multidisciplinary work and, often, the experience of working in international environments. In this regard, both inter-sectoral and intra-sectoral mobility play an important role.

Transferable Skills

The discussion on transferable skills proved to be the most controversial aspect of the DOC-CAREERS university-industry dialogue.

While there was a general agreement that such skills are important, there was less consensus on the extent to which they should be a structural element of doctoral education. SMEs placed a higher value in doctorate holders with the "soft skills" to complement their research capabilities at the moment of being employed, while for large R&D companies, the value of hiring a doctorate holder usually lies, in the first instance, in a deep knowledge of a relevant subject and broader competencies that are likely to equip the person to handle subsequent career challenges.

Collaborative Doctoral Programmes

The examples illustrated by the DOC-CAREERS case studies confirmed excellence in research as a hallmark of success. A common pattern emerged from the different formulae of collaborative doctoral programmes identified, characterised by seven main components: strategic level of engagement in the parent organisations, role of industrial partner, selection of the doctoral research topic, additional admission requirements, formal agreement (including Intellectual Property Rights), and legal status of the doctoral candidate. Practitioners in all sectors and fields agreed that, independently of how well-organised a collaborative programme may be in formal terms, success also depends upon the quality of the personal component, including the ability to team up to solve problems, achieve excellent performance, and establish good levels of mutual trust between the stakeholders.

Next to the necessary role of the external partner as part of the supervisory team, placements in industry facilities are seen as one of the most important contributions that an industry can offer to the training of a doctoral candidate wishing to obtain insight into the business world (e.g. from using business labs and participating in business meetings to having lunch in the canteen).

Views of Stakeholders

DOC-CAREERS university case studies highlighted a number of benefits from collaborative doctoral programmes such as promoting innovation, entrepreneurship and social responsibility, incorporating industry input to university research, gaining awareness of industry's technological challenges and contributing to sustainable funding for research. In analysing the impact of collaborative doctoral education, DOC-CAREERS university case studies reported tangible and intangible benefits for the persons directly involved in the project, doctoral candidate, university and industry supervisors, to the institutional and organisational benefits and to a broader positive impact on the city/region. For example, when looking for employment, doctorate holders take with them the reputation of a good collaborative scheme that funded the research and the names of the university and company involved.

The doctoral candidates and holders that participated in DOC-CAREERS reported several main challenges compared to their peers in more traditional doctoral programmes (e.g. balancing their time properly between university and industry activities, having to draft multiple reports with the same research outcomes, possible constraints of pre-established boundaries of the research). However, in general, doctoral candidates valued the expanding range of employment opportunities outside academic environments and agreed that, as in any other kind of employment, different positions may require different sets of skills.

Despite their coverage of different industrial sectors and innovation profiles, the general views offered by companies on what they expected from doctorate holders were quite uniform, as were their perceptions of the strengths and weaknesses of doctorate holders in their first time in an industry environment. In general, companies were very satisfied with the acquired knowledge and research skills of doctorate holders educated in Europe, but also pointed to the need for greater communication skills, and the limited awareness of intellectual property issues and understanding of how businesses operate.

Data Tracking

The project's work on data tracking of doctoral careers reported on the paucity of examples of institutional data tracking. The many benefits of career tracking and the information gathered include further exploration of the skills and competencies that doctorate graduates require to inform programme curricula development and hence attracting future doctoral candidates. Main challenges include the need for coverage of academic and non-academic career paths, and the difficulty of comparing data outcomes collected from different institutions according to their individual needs. While new (soft) tools are required to address some of these challenges (e.g. making more use of alumni networks), considerable progress can be made simply by adopting existing good practices and taking advantage of technological developments in software.

Enhanced Dialogue and the Role of Government

The enhanced dialogue required to achieve more effective university-industry cooperation can be promoted at many levels. Investing in developing the soft part of the relationship – proximity for easy opportunities of meeting, one-to-one dialogue, etc. – is essential and such platforms for dialogue should be developed: between university and industry but also within university disciplines and industrial sectors to favour trans-disciplinary and trans-sectoral exchange.

The committed support of governments is also essential, as facilitators of university-industry collaboration, specifically in doctoral education, and should include initiatives to address structural issues that are outside the capacity of the individual research actors. Many DOC-CAREERS case studies demonstrated that collaborative programmes require for their sustainability the continued support from governments and funding bodies. Government funding support and its necessary accountability requirements provide organisational structure and help to enhance quality. In general, this structure results in better joint supervision and placements that prove to be satisfactory for all parties: university, industry and doctoral candidates. Public support is, furthermore, much more important for SMEs than for large R&D intensive companies that have the resources to manage on-going collaborations.

The evidence collected during DOC-CAREERS has demonstrated that universities and enterprises share many views on the opportunities, challenges and barriers associated with university-industry cooperation. In this sense, the "diagnosis" of the situation is sound and the common barriers in Europe are well identified. Nonetheless, the DOC-CAREERS case studies also confirmed that these barriers can be overcome. There are no "one-size-fits-all solutions" and successful approaches tend to incorporate local or regional cultural specificities as captured in the phrase "the way we do things here". However, all successful approaches are based on mutual trust and understanding, and not on an expectation that one party should contribute to another's objectives. In order to assess the true importance of this diversity, follow-up actions are required which look more specifically at how universities work with their regional partners in doctoral education.

1 Introduction

DOC-CAREERS in EUA and EU Policy contexts

The era of the "knowledge-based economy" has brought into focus the dynamics of the relationship between universities as catalysts of knowledge production and the economy and society as users and adaptors of knowledge for products and services and civic purposes. Universities are seen increasingly as playing a pivotal role in strengthening the economic competitiveness of Europe as a global region, based on the knowledge and skills these institutions generate. One outcome of the current political and policy debate on this central challenge of competitiveness in a knowledge-based economy has been to place greater emphasis on the main responsibilities of universities as suppliers of trained researchers capable of anticipating and meeting the demand in competitive sectors such as information and communication technology, energy technology, biotechnology, life sciences, medicine and health services, etc. Furthermore, the policy narrative looks to universities as institutions to foster a stronger "entrepreneurial culture" amongst university graduates to innovate and create their own enterprises.

The European University Association (EUA) has been a prominent independent partner in the "Third Cycle" of the Bologna Process focusing on doctoral education. EUA has sought to bring forward European universities' current experiences and new perspectives on needs and requirements into the process of intergovernmental cooperation on policy development in higher education reform. In 2005, EUA published its first project report entitled "Doctoral Programmes for the European Knowledge Society"[1] which undertook a broad overview of doctoral education in Europe with particular focus on the growing trend towards the development of structured doctoral programmes in the place of the traditional individual study programmes. With the participation of 48 universities from across Europe, the project established an "evidence-based dialogue" reflecting on the present landscape of doctoral education, current practices and innovations, and issues for reform. The emphasis of this "dialogue" between university partners and higher education policy makers and practitioners has been on how doctoral programmes, through their pursuance of original research combined with transferable skills development, were widening options for doctoral candidates' research careers in academia, government and the private sector and increasing generally the supply of highly-skilled professionals needed in the competitive labour markets of the new "knowledge economy".

Creating and maintaining this open dialogue as a key innovative feature has been a major priority for EUA's work in examining doctoral education reform in Europe's universities. The results of the first project were instrumental in establishing the Bologna Process Salzburg Conference (February 2005) "Ten Basic Principles"[2] for the future development of doctoral education which were built subsequently into the recommendations adopted by the Conference of European Ministers for Higher Education held in Bergen, Norway, in May 2005. Following-up these recommendations, EUA conducted further work within three clusters of issues relating to: the quality of doctoral programmes - access, supervision, monitoring and assessment, and transferable skills development and its relationship to employability; the development of structured programmes, critical mass-building through doctoral schools promoting internationalisation and mobility; and the funding of doctoral education in the various national and legal regulatory frameworks. In 2007, the results of this further work were published in the report "Doctoral Programmes in Europe's Universities: Achievements and Challenges"[3]. Its overall conclusions were presented subsequently to the Conference of European Ministers for Higher Education held in London, United Kingdom, in May 2007 and published simultaneously as "EUA's Contribution to the Bologna Ministerial meeting, London 2007"[4].

1. http://www.eua.be/eua/jsp/en/upload/Doctoral_Programmes_Project_Report.1129278878120.pdf
2. Bologna Seminar on Doctoral Programmes for the European Knowledge Society, 2005, http://www.eua.be/eua/jsp/en/upload/Salzburg_Conclusions.1108990538850.pdf
3. http://www.eua.be/fileadmin/user_upload/files/Publications/Doctoral_Programmes_in_Europe_s_Universities.pdf
4. http://www.eua.be/fileadmin/user_upload/files/Publications/EUA_Bologna_ministerial_meeting.pdf

An important aspect of EUA's work has been to highlight the range of "collaborative doctoral programmes" that exist between universities and external partners in both the private and public sectors - some are already well-established, while others have developed as an innovative response to the demands of evolving labour markets requiring specialised research and professional skills. These collaborative doctoral programmes merit particular attention in terms of the prospects they offer to doctoral candidates of widening the horizons of their research careers outside academia, and to universities of establishing new external partnerships for broadening and developing their research missions. Hence the new project entitled "DOC-CAREERS: From Innovative Doctoral Education to Enhanced Career Opportunities"[5] was devised and its findings are the subject of this report.

A key partner in the conduct of this study has been the European Industrial Research Management Association (EIRMA). Since 2005, when EUA, together with EIRMA, the European Association of Research and Technology Organisations (EARTO), and Proton Europe (the European Association of knowledge transfer offices) published "Responsible Partnering: A guide to better practices for collaborative research and knowledge transfer between science and industry"[6], this groundwork has established mutual trust and sound cooperation between university and industry partners through several conferences and workshops validating good practice and providing examples of take-up by universities and businesses both large and small.

The "Responsible Partnering Guidelines" cover core areas that are crucial to university/industry collaboration, including aligning interests, professional training and skills, consortia-building, intellectual property rights and patents, and finally and most importantly, building lasting relationships in collaborative research. The guidelines have been recognised as a pioneering European initiative in European Commission Communications and Recommendations on improving knowledge transfer and the management of intellectual property rights and were strongly recommended for further implementation by the Aho Report on "Creating an Innovative Europe"[7]. The guidelines have provided a focused and practice-orientated basis for discussion and exchange with industry at key events such as the European Business Summit and the University-Business Forum.

Building upon the framework of the Responsible Partnering collaboration and with the support of the European Commission, DG Research, the "DOC-CAREERS" project has examined a range of collaborative doctoral programmes across Europe, which are conducted jointly by universities and industry/business partners. In this report, the approaches and characteristics of these collaborative doctoral programmes are explored, whether government, university or industry-led, and the perspectives, expectations and experiences of the partners from university and industry and not least the doctoral candidates themselves are examined. With over 50% of doctorate holders moving into careers outside the academic sector, the importance of such collaborative programmes is evident. The value of the promotion and dissemination of good practices in such collaborative doctoral programmes, the achievement of inter-sectoral mobility, the development of transferable skill components and the broadening of employment horizons cannot be over-estimated, considering the objectives of strengthening universities' and researchers' capacity to contribute towards more competitive European economies and a stronger European Research Area.

EUA sees the results of this project, therefore, as bringing important empirical evidence to the European policy debate on the "Modernisation Agenda for Europe's Universities."[8]

5. http://www.eua.be/research/doctoral-programmes/doc-careers/
6. The guidelines were fully endorsed by the Aho group in the Report "Creating an Innovative Europe" and were acknowledged as European good practice in the European Commission Communication (COM(2007) 182 final) on "Improving knowledge transfer between research institutions and industry across Europe: embracing open innovation". The guidelines were reviewed at a recent conference held in Lisbon (December 2007) convened by EUA with the support of EC DG Research. http://www.responsible-partnering.org/library/rp-2005-v1.pdf and http://www.responsible-partnering.org/library/sc-2007-01.pdf
7. http://ec.europa.eu/invest-in-research/pdf/download_en/aho_report.pdf
8. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0208:FIN:EN:PDF

1 Introduction

This agenda has emphasised the need for universities to work more extensively with external partners in all aspects of their mission, referred to in current policy language as the "knowledge triangle" encompassing education, research and innovation. In addressing this agenda, it links also to EUA's project work on how to achieve financially sustainable universities through increasing partnerships and diversifying income streams and the parallel need for universities to have greater autonomy in defining and pursuing their missions[9].

The report aims also to contribute to the European policy debate surrounding the "Barcelona target", by highlighting ways to increase the number of highly skilled researchers capable of supporting the goal of global leadership in knowledge production and innovation. It illustrates a growing number of innovative approaches in establishing collaborative doctoral programmes, initiated by universities themselves and by industry partners, and types of stimulus and financial support provided by government funding agencies. These exemplar research programmes offer a range of "good practices" that could be further taken up across Europe.

A few key figures for research in EU-27

The Community Innovation Survey[10] indicated that between 2002 and 2004, only 9% of innovative European companies had established collaborations with universities and only 6% with governments and research institutes. These figures have been confirmed by a recent OECD study[11], which includes extensive information on the type of collaborations with both large industry and SMEs. These reports highlight also that large companies are four times more likely than SMEs to collaborate on innovation.

The recent European Commission report "A more research-intensive and integrated European Research Area"[12] gives an overview of trends in research and innovation in Europe and in comparison with other areas in the world[13]. Amongst the extensive data that is presented, the following can be highlighted as relevant background to the present report:

- The number of full-time equivalent (FTE) researchers in the EU-27 increased by about 15% between 2000 and 2006 (1,300,900 FTE in 2006).
- The number of FTE researchers employed in the business sector increased by between 2% and 5.5% per annum during the same period.
- In 2005, the EU-27 produced some 100,000 doctoral graduates, compared to 53,000 in the US and 15,000 in Japan in the same year. (The EU-27 awards approximately 15% more doctorate degrees per capita than US and 23% more per capita than Japan).
- Total R&D investment increased from 2000 to 2006 by 14.8%, while GDP increased 13.7%. This indicates that there has been no structural change in R&D intensity in the EU economy over the period in relation to targets of 1% and 2% of private and public investment, respectively.
- Between 2000 and 2005 there has been an average annual growth on the number of doctoral graduates of 5% in EU-27, 3.3% in US and 4,6% in Japan.

A recent OECD report[14] includes statistics on trends in numbers of doctorates and percentage of doctorates in science and technology. While the absolute number of doctorates increased by a few percentages in most reported countries during the period 1993-2003, the proportion of doctorates in science and technolgoy declined in every reported OECD country except Korea. In relation to international mobility of doctorate holders, another OECD report[15] provides varied percentage of doctorate holders from Europe having lived abroad, from 3.5% in Lithuania to 32% in Cyprus.

There are, of course, many differences across EU countries and regions, but this snapshot of EU figures indicates both the steady growth in research employment in recent years and the significant number of people who are gaining doctoral qualifications. Nevertheless, Europe has difficulties in moving towards a more research-intensive economy, which is considered key to

9. http://www.eua.be/fileadmin/user_upload/files/Publications/Financially_Sustainable_Universities.pdf
10. Fourth Community Innovation Survey (February 2007) http://europa.eu/rapid/pressReleasesAction.do?reference=STAT/07/27&type=HTML; Community Innovation Survey 2004-2006 (March 2009) http://www.cso.ie/releasespublications/documents/information_tech/2006/comminn0406.pdf
11. Open Innovation in Global Networks, OECD 2008
12. http://ec.europa.eu/research/era/pdf/key-figures-report2008-2009_en.pdf
13. Detailed data available in OECD and Eurostat reports.
14. OECD 2008 "Encouraging Student Interest in Science and Technology Studies"
15. OECD 2008 "Data Collection on Careers of Doctorate Holders: State of the Art and Prospects"

Europe's future competitiveness in relation to the US, Japan and the emerging economies of China, India and Latin America.

An increasing need for partnerships

Innovative activity and capabilities are essential for economic growth and development. Today, market competitiveness is based on the capacity of innovation rather than just on the reduction of costs. R&D is a main component of innovation activities and for R&D-intensive companies, both large and SME, internationalisation of R&D is crucial[16]. It has been demonstrated that firms are well able to increase their innovative capabilities by the use of strategic technology alliances, being the most important external sources of technology for industry involving universities, consortia, licensing, customers and suppliers, acquisitions, joint ventures and commercial research organisations[17].

University-industry research relationships are not a new phenomenon. Science historians have traced the collaborations that have been established between European companies and university researchers since the 1800s, and shown the importance attached to these collaborations as important sources of knowledge and as an easy way to carry out research. However, from 1910s until 1960s the externalisation of R&D decreased steadily from about 20% to 3%[18] as central corporate R&D laboratories became more widespread. Since then, the externalisation of R&D has again grown and is estimated to have reached 18% in 2005-2006. A diverse set of developments underlies these trends but the main difference between the 20th century and today is an evolution from strict outsourcing of R&D with limited or non-existent strategies[19] to the development of coherent networks of partnerships with suppliers, competitors and also with universities, within the framework of a global corporate strategy for R&D[20] in which the mixture of internal resources and external partnerships is seen to offer the best means to support innovation within the company.

In 2003[21], Henry Chesbrough termed this phenomenon "Open Innovation." The paradigm emphasises the advantages of using external as well as internal ideas and developments, and has been adopted, interpreted and developed in many different ways by companies, generating a diversity of approaches to R&D and innovation[22]. Cooperation with universities is an important part, including joint scientific projects, scientific exchanges, sabbaticals, international flows of students, joint ventures for specific projects firms, production agreements with exchange of technical information and/or equipment.

A first structured programme designed to nurture university-industry collaboration was set up in 1948 by the Massachusetts Institute of Technology (MIT), the Industrial Liaison Program (ILP), and remains in place today[23]. In Europe, the expression 'European Paradox' was popularised by the first 'European Report on Science and Technology Indicators' (European Commission, 1994), suggesting that Europe played a leading world role in terms of scientific excellence and the provision of highly skilled human capital, while largely failing to convert science-based findings and inventions into wealth-generating innovations. Believing that this weakness reflected (at least in part) an inadequate flow of knowledge between the worlds of academia and industry, from the 1980's many European governments gave increasing priority to designing and implementing structured initiatives to support university-industry relations to increase competitiveness at national level, and at the EU level through the development of the European Commission Research Framework Programme and its range of instruments. Today, the European Institute of Innovation and Technology initiative is a prominent example of the new instruments being designed for this purpose. These national and European programmes are today clear drivers, alongside corporate and institutional strategies, in fostering university-industry partnerships.

Drivers for partnerships include of course the need for technological developments, and shortening their time-to-market, but non-

16. World Investment Report, 2005, http://www.unctad.org/en/docs/wir2005_en.pdf, chapter III.
17. Narula and Duysters, 2004
18. TNO/Roland Berger, 2003
19. Arnoud de Meyer & Atsuo Mizushima, R&D Management, No. 19(2), 1989.
20. http://www.realinstitutoelcano.org/materiales/docs/OCDE_handbook.pdf
21. Henry Chesbrough, Open Innovation: The New Imperative for Creating and Profiting from Technology, Boston: Harvard Business School Press, 2003, ISBN: 1-57851-837-7.
22. Open Innovation in Global Networks, OECD 2008
23. http://ilp-www.mit.edu/display_page.a4d?key=P2a

1 Introduction

technological developments are also essential[24]. The economic and social sciences also play a crucial part in assisting industry to adapt their strategies and organisational systems to the changing global frameworks[25] and in assisting society to digest the fast pace of technological progress. Doctorate graduates are natural and principal transmittors of the solid background knowledge required to support innovation and hence they do not only find employment in academia and business enterprise. Doctorate graduates are prominent increasingly in other sectors of the labour market - e.g. governments, private non-profit organisations, consultancies, other education sectors, and the service sector - as statistics demonstrate[26,27], and as several universities participating in this study confirmed with their own data on employment outcomes of their doctoral graduates.

University-industry partnerships directed towards doctoral education have also existed for some time in Europe, with greater or lesser degrees of formality and with more or less involvement from industry. Large structured initiatives, such as the Industrial Research Programme in Denmark, started in the 1970s. In early 1989, this programme was changed to a three-year PhD course under the Danish Council for the Promotion of Industrial Development and in 2000 responsibility was transferred to the Ministry of Science, Technology and Innovation[28]. In France, the French Ministry of Higher Education and Research created the CIFRE Programme (Convention Industrielle de Formation par la Recherche) in 1981 as a national effort to improve the professional integration of doctorate holders in companies. In the United Kingdom, the Research Councils have offered industrial CASE awards (Cooperative Awards in Science and Engineering) for many years to provide doctoral training in a partnership between an academic institution and a cooperating company. In 1994 CASE award opportunities were extended beyond science and engineering fields to include the social sciences, and in 2004 to the arts and humanities. At the European level, the Marie Curie Actions with their recent emphasis on Academia-Industry partnerships in research training networks and the use of the European Social Funds for doctoral research linked to regional social and economic development play an increasingly important role in building collaboration.

The DOC-CAREERS project has collected practices and experiences from universities participating in the types of established programmes mentioned above. It has also, importantly, gathered evidence from universities at different stages of development of their university-industry relations, and taken account of their different national and regional contexts. The project aims to contribute to fostering university-industry partnerships in general, with a particular focus on the effectiveness of collaborative doctoral programmes. The clear benefits expressed widely by the main three groups of practitioners, universities, industries, doctorate candidates and holders, indicate that collaborative doctoral programmes are indeed an excellent vehicle, both to foster innovation and also to sustain long-term fruitful relationships while maintaining the core values and missions of each partner.

The project focuses on the processes involved in setting up and taking forward collaborative doctoral programmes and on the main added value of these programmes concerning the exposure of the doctoral candidate to industry environments. The analysis does not focus on specific disciplines but, taking account of different disciplinary contexts and cultures, addresses three broad areas of knowledge, namely Science, Engineering and Technology (SET), Biotechnology, Medical and Life Sciences (BML) and Economics and Social Sciences (ESS). Based on 33 European university case studies, 31 European R&D-based company case studies and several case studies supplied by other stakeholders, the project identifies main trends in collaborative doctoral programmes in these three broad areas of knowledge in an attempt to promote the transferability of lessons learned across disciplines and to reflect upon the different perspectives – from industry, university and doctoral candidate – and hence to encourage future collaborations.

24. OECD, Indicators of Non-Technological Innovation, 2007 OECD Handbook on Economic Globalisation Indicators, 2005, p. 18, http://www.realinstitutoelcano.org/materiales/docs/OCDE_handbook.pdf
25. OECD Handbook on Economic Globalisation Indicators, 2005, p. 18, http://www.realinstitutoelcano.org/materiales/docs/OCDE_handbook.pdf
26. OECD Data Collection on Careers of Doctorate Holders, 2008
27. UK GRAD Programme; What do PhDs do?, 2004 & The UK Grad Programme.; Recruiting PhDs: What works?, 2006
28. "The Industrial PhD - An effective tool for innovation and knowledge sharing", 2007

2 The Project and its European Dimension

2.1. Objectives, General Approaches and Methodologies

The DOC-CAREERS project[5] "From Innovative Doctoral Training to Enhanced Career Opportunities" was designed to explore the relationship between doctoral education and the employability prospects for doctorate holders in the academic and non-academic labour markets. The project was funded by DG Research through a FP6 Specific Support Action. The project sought to obtain comprehensive good practice information for recommendations for the development of collaborative doctoral programmes for the benefit of universities and other stakeholders and to feed into policy dialogue in the area. The specific issues addressed were:

i) The development of transferable skills and competencies in doctoral programmes to enhance employability and career perspectives in private and public sectors

ii) The extent of existing university and industry collaboration in doctoral programmes

iii) Mobility Strategies for Career Development (inter-sectoral mobility and intra-sectoral)

iv) Requirements for more systematic collection of data at the university level to provide the basis for the analysis of doctoral candidates' career paths.

DOC-CAREERS research has built upon the findings of a previous EUA study[1] of practices and experiences of doctoral programmes across Europe which confirmed that most universities prepare doctoral candidates mainly for careers in academia despite the fact that a high proportion of candidates find their employment elsewhere. It also built upon the outcomes of the Bologna Follow-Up Group (BFUG) studies and seminars between 2005 and 2006 on the progress in the reform of doctoral programmes in Europe[3]. Within the context of the EU Lisbon and Barcelona policy objectives and the European Commission "Green Paper on the ERA: New Perspectives"[29] it is crucial to prepare more researchers for employment in industry and other sectors of the economy and to open career paths between private and public sectors.

The project's four chosen issues (above) are interconnected and the project activities were designed to reflect an integral approach. A Steering Committee composed of experts from different sectors (university, enterprise, doctorate holders and other stakeholders – Annex 7.2.) was invited to monitor the project and ensure contributions from a sufficient variety of stakeholders. The Steering Committee launched several dialogue activities with and between universities, enterprises and other stakeholders. The latter group included representatives from professional networks, research offices, career development offices, government bodies and other policy makers. For a proper dialogue to ensue, information was collected on existing collaborative doctoral projects and first hand experiences were shared between practitioners, namely scientists, enterprise managers, doctorate candidates/holders, and other stakeholders concerned about the employability of doctorate holders and their broader generic skills.

Since skill requirements and the nature of university-business collaboration and mobility strategies seemed likely to vary according to the field of knowledge, three distinctive areas were selected for special study:

[29] Green Paper "The European Research Area: New Perspectives", COM(2007) 161 final, Brussels, 4.4.2007 http://ec.europa.eu/research/era/pdf/era_gp_final_en.pdf

2 The project and its European Dimension

- Science, Engineering and Technology (SET)
- Biotechnology, Medical and Life Sciences (BML)
- Economics and Social Sciences (ESS)

Fig. 2.1-1 indicates the different types of input to DOC-CAREERS from the dialogue activities which included:

i) Workshops[30]

The First Workshop (La Fondation Universitaire, Brussels) addressed the degree of alignment between universities and industry in what is understood as transferable skills for doctoral graduates in the three selected fields, looking particularly at the links between doctoral programmes and employment opportunities for researchers in the public and private labour markets. The workshop convened 26 experts from 13 countries, of which 9 were representatives from universities or university networks, 11 from professional bodies, 3 from government bodies and 3 from companies with strong research activity. After the workshop a number of participants voluntarily provided free-format contributions on the issue of transferable skills in their organisations.

The Second and Third Workshop of DOC-CAREERS were hosted by two companies, Siemens and Schlumberger, as a symbol of promotion and reinforcement of university-industry dialogue for mutual benefit:

The Second Workshop (Siemens AG, Munich-Perlach) analysed the nature and extent of existing university-industry collaboration in doctoral programmes (funding, supervision, etc.), the necessary structural conditions and drivers for universities and industry to become involved and succeed in long-term collaborations, and the perceived value of mobility in enhancing employability of doctorate holders. The workshop gathered 24 experts from 13 countries, of which 11 were representatives from universities or university networks, 9 from professional bodies, 2 from government bodies and 1 from the corporate world. More representatives from industry had confirmed their participation but unfortunately had to cancel at the last minute due to unavoidable commitments related to their businesses. We encountered these understandable situations also in the previous workshop and they are illustrative of one of the difficulties in building structured dialogue with industry.

The Third and Final Workshop (Schlumberger, Paris-Clamart) discussed and validated the main findings from the range of inputs to the project. The workshop gathered 42 experts involved in doctoral education in cooperation with universities. Participants came from 16 European countries representing the business sector (17%), the university sector (43%), professional bodies (36%), and government bodies (5%). A high percentage of these participants (63%) attended a DOC-CAREERS workshop for the first time, giving the validation process a good level of legitimacy.

ii) University Case Studies

The purpose of the university case studies was to identify initiatives, good practice and potential models of collaborative doctoral education. Universities were invited to participate through two calls for expressions of interest published on the EUA website. Universities were selected based on the evidence of industrial involvement in doctoral research, and disciplinary and geographical spread throughout Europe. EUA developed a Questionnaire and Guidelines comprising 40 questions for universities to provide details on how they established partnership with industry: their motivations, incentives and challenges; the characteristics of their collaborative doctoral schemes; their impact and sustainability; and the number of doctoral candidates involved in collaborative doctoral education and their employment destinations if known. A total of 17 universities from 14 European countries responded in detail to the questionnaire. Their contributions, in the form of written reports, were mainly of a qualitative nature, through open-ended questions intended to collect the particularities

30. Outcomes and presentations each of the workshops are available at: http://www.eua.be/research/doctoral-programmes/doc-careers/

of each case and facilitate an understanding of the diversity of approaches. Section 2.2. provides full details on the selection criteria and characteristics of the sample of universities.

iii) Consultation with Industry

Consultation with companies sought to ascertain their views on doctoral education and doctoral employability. Large R&D Europe-based corporations were interviewed in cooperation with EIRMA. Consultation with SMEs included interviews with a few companies suggested by partner universities. Additional input on SMEs was given by universities through case study material.

The large companies were identified by the EIRMA secretariat from its membership, based on four criteria covering technological and non-technological innovation activity, sales volume, industrial sectors and geographical location in Europe. On the basis of the Questionnaire developed by EUA for the university case studies, EIRMA issued a parallel Questionnaire with 44 questions to collect companies' views and experiences on: the recruitment of doctorate holders, selection of partner universities, the setting-up of collaborative schemes, their contribution to doctoral programmes and the lessons learned. The survey was conducted by scheduled 30-minute phone interviews and through site visits to CEOs, Directors of R&D Departments and Directors of Human Resources Departments.

In total, 31 companies participated in the survey questionnaire. 28 of these were EIRMA members and 3 were appointed by case study participants. Section 2.3. provides details on the selection criteria and the sample profile of the companies. The limited size of the survey sample, type of company and the open-ended nature of the questions did not allow to draw many quantitative conclusions regarding industry relations with the academic world and doctoral candidates but it was sufficient to provide a realistic image of the world of innovation in large corporations in Europe, useful for the qualitative analyses foreseen in the DOC-CAREERS project.

iv) Consultation with Doctoral Candidates/Holders and Other Stakeholders

Doctoral candidates/holders involved in doctoral education with industry were consulted in two ways. Firstly, EURODOC developed a Questionnaire with 25 questions based on the EUA questionnaire for the university case studies. Secondly, some of the universities that submitted case studies included outcomes of their internal surveys with doctoral candidates/holders. The views presented in this report are an aggregation of all contributions received.

Other relevant stakeholder organisations participating in the dialogue workshops provided input either as a case study and/or as experts in the field. Association Bernard Gregory (ABG), France, provided ad-hoc formal information on their ways and means of helping doctoral candidates and holders to prepare for the labour market outside academia.

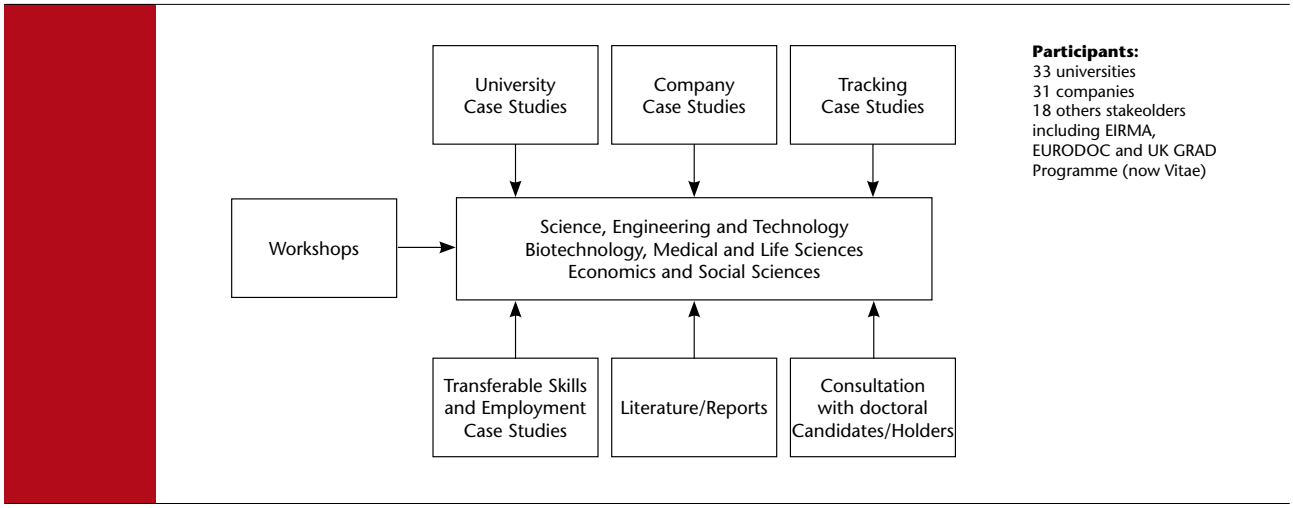
v) Data Collection and Tracking of Doctorate Holder Careers Study

The purpose of this study was to identify the methodologies that institutions use to collect data on doctoral graduates' careers and that could have potential wider application and transferability to other environments. This practice would allow universities to explore the relationships between doctoral training programmes and the career development and employability of doctorate holders, especially in sectors outside of higher education. The exercise built on the findings of the previous EUA Doctoral Programmes Project[1].

A specific Working Group (members listed in Annex 7.2.) chaired by Janet Metcalfe, UK GRAD Programme (now Vitae), was set up to carry out this exercise. Several methodological issues on data collection and tracking of doctorate holders were analysed through a questionnaire of 27 close-ended inquiries with room for comments developed by the Working Group. Calls for expressions of interest were launched through the EUA website for members to contribute case studies on sound practice in data collection and tracking methods. A total of

2 The project and its European Dimension

Figure 2.1-1 Types of input to DOC-CAREERS project



Source: EUA DOC-CAREERS Project

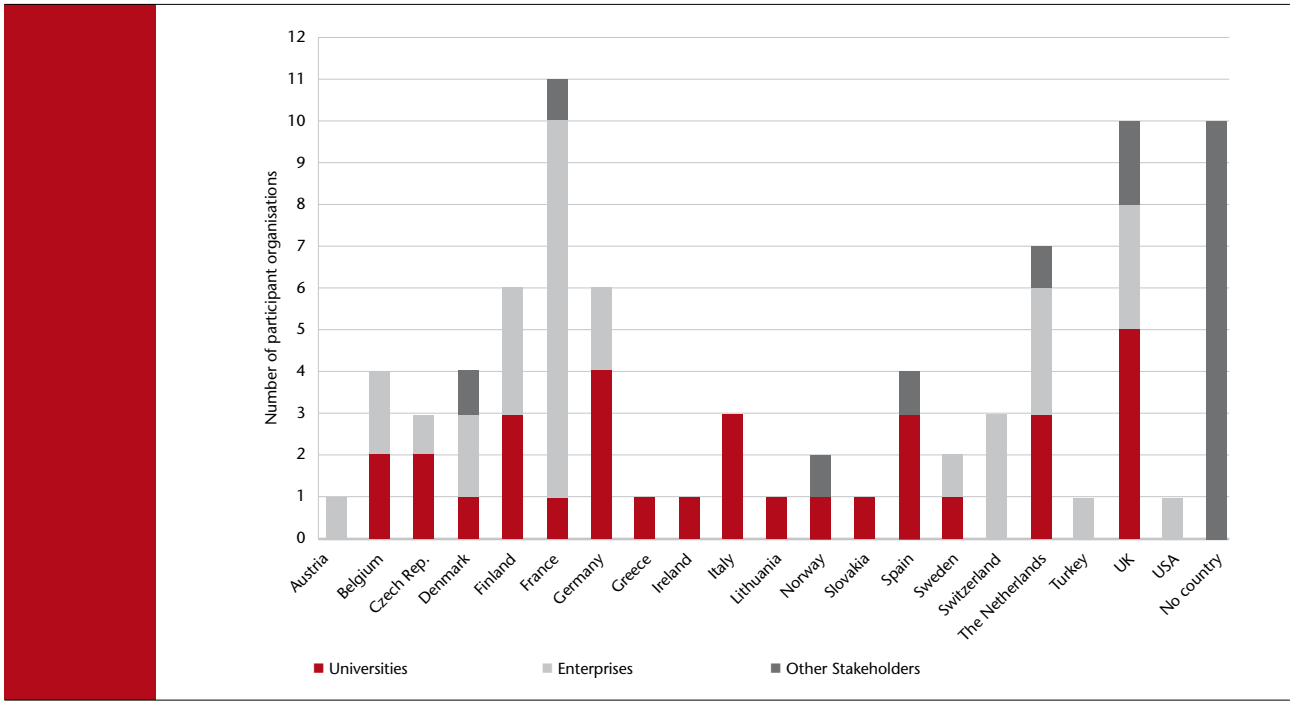
11 institutions contributed, 8 universities plus OECD, HESA and EMBO. The questionnaire explored the particular rationale for the tracking studies, the key features of the data collection mechanism, the methodology and data analysis used, the resources required, and the benefits gained and challenges encountered. Respondents were also asked about their future plans for their tracking studies and whether they thought the methodologies were transferable. Entries were reviewed and analysed by the Working Group in terms of the advantages and disadvantages of various methodologies and approaches. The Group identified themes emerging from the analysis and developed recommendations.

In summary, DOC-CAREERS received contributions (Fig. 2.1-1) from 82 organisations including 33 universities, 31 enterprises and 18 other stakeholders from 19 European countries (Fig. 2.1-2). A comprehensive list of the participant organisations, the people who were directly involved and their contributions appears in Annex 7.1. Four organisations made a special contribution by acting as mediators for dialogue with specific stakeholders: The European Industrial Research Management Association (EIRMA)[31] actively contributed by involving medium-large R&D intensive enterprises in the consultation with industry. The European Council of Doctoral Candidates and Young Researchers (EURODOC)[32] gave input from doctoral candidates and holders. The study on methodologies for data collection and tracking of doctorate holders' careers was led by UK GRAD Programme[33]. The European Doctoral Programmes Association in Management and Business Administration (EDAMBA)[34] coordinated the consultation with management and business administration academic institutions and provided overarching views on the sector.

Principal representatives from all participant organisations provided detailed information and data available through written reports or personal interviews. The project created a great deal of interest and many representatives followed up the project activities. During the development of the project, a significant long-term dialogue with people and organisations was initiated and consolidated.

31. The European Industrial Research Management Association (EIRMA) is an independent, not-for-profit organisation which deals with the effective global management and organisation of business R&D and innovation within a European perspective. EIRMA engages over 150 major companies which are based in over 20 countries and operate in a wide range of sectors. Its aim is to help companies to improve the performance of their R&D and enhance innovation. www.eirma.org
32. EURODOC takes the form of a federation of national associations of doctoral candidates and young researchers. http://www.eurodoc.net
33. UK GRAD Programme is now Vitae, a national organisation championing the personal, professional and career development of doctoral researchers and research staff in higher education institutions and research institutes. http://www.vitae.ac.uk/
34. The purpose of EDAMBA is to promote and facilitate cooperation within the European Doctoral Programmes Association in Management and Business Administration by providing and managing a network to exchange information, to exchange PhD candidates and to promote research cooperation. http://www.edamba.eu

Figure 2.1-2 Country breakdown of DOC-CAREERS cases by type of participant



Source: EUA DOC-CAREERS Project

2.2. The Universities and Other Stakeholders Case Studies

The 33 universities and 18 other stakeholders' participant organisations provided views and data on issues related to doctoral education in collaboration with industry, transferable skills, employability and careers of doctorate holders. The institutions, their specific contribution and the principal persons from the organisations involved in DOC-CAREERS are listed in Annex 7.1. Major contributions came from those universities which submitted extensive written reports on their practices and data on doctoral education in cooperation with industry (University Case Studies). Other universities and organisations provided free-format written input on transferable skills issues and employment of doctorate holders (Transferable Skills and Employment Case Studies). Finally, universities and other organisations participated in the tracking survey (Tracking Case Studies). The main characteristics of the case studies and other contributions are set out below.

DOC-CAREERS University Case Studies

University case studies of doctoral programmes in cooperation with industry were identified through two calls for Expressions of Interest on the EUA website (December 2006 and June 2007) and announcements made in EUA workshops. The Steering Committee decided to work exclusively with the universities that expressed their interest in participating. Initially, the project planned to study 6 European university cases. Due to the increased number of expected expressions of interest received, and the diversity of countries and approaches, the number of university case studies was enlarged to 17. Case studies were selected by taking into account three criteria: i) Evidence of industry involvement in doctoral research; ii) Balance of field of research in the three selected areas of study (SET, BML, ESS); and iii) Geographical spread throughout Europe.

2 The project and its European Dimension

Each university presented a report on their good practices, experience and available data responding to a 40-question survey developed by EUA (Annex 7.3.). The universities themselves selected the particular doctoral programme or scheme that they wanted to contribute to DOC-CAREERS. The general characteristics of the University Case Studies are in Table 2.1-1.

Table 2.1-1 Summary of DOC-CAREERS university case studies

Institution	University Doctoral Department/ Programme/School	Main Initiative Driver	Main Funding Source	Main Funding Agency or Programme	Discipline Field
Aarhus School of Business, University of Aarhus, DK	Aarhus School of Business	Individual	Government, Funding agencies	Danish Industrial PhD	ESS
ERIM, Erasmus University Rotterdam, NL	Erasmus Doctoral Programme in Business and Management	Individual	Depends on the project	Depends on the project	ESS
Masaryk University, CZ	Masaryk university doctoral programmes	Individual	Depends on the project	Depends on the project	SET, BML, ESS
University of Cagliari, IT	Economia e gestione aziendale	Individual	Depends on the project	Depends on the project	ESS
Uppsala Universitet, SW	Department of Business Studies	Individual	Depends on the project	Depends on the project	ESS
Matej Bel University, SK	Matej Bel university doctoral programmes	Individual	Depends on the project	Depends on the project	ESS
Athens University of Economics and Business, GR	Department of Management Science and Technology	Institutional	Government, Funding agencies	PENED Programme	ESS
ESADE Business School, ES	PhD in Management Sciences	Institutional	Government, Funding agencies	Catalan & Spanish Government and EC Funds	ESS
Mykolas Romeris, LT	University-Business Cooperation Scheme in Social Sciences	Institutional	Government, Funding agencies	European Social Fund	ESS
Newcastle University, UK	CASE Collaborative Studentships	Institutional	Government, Funding agencies	CASE	ESS
Technische Universität Ilmenau, DE	Technische Universität Ilmenau doctoral programmes	Institutional	Government, Funding agencies	Depends on the project	SET
University of Wales – Bangor, UK	Phase I: Developing Research Skills (2004-2007). Phase II: Research Skills Training (2005-2008)	Institutional	Private and Government, Funding agencies	European Structural Funds	SET, BML, ESS
Hanken Swedish School of Economics and Business Administration, FI	HANKEN Doctoral Programme	Institutional together with Government	Government, Funding agencies	TEKES	ESS
Université Pierre et Marie Curie, FR	House of Doctoral Schools	Institutional together with Government	Private, Government, Funding agencies	CIFRE	SET, BML
University of Paderborn - (PACE), DE	Dynamic Intelligent Systems	Institutional together with Government	Government, Funding agencies	North Rhine-Westphalia Region	SET
Delft University of Technology, NL	TRAIL, the Netherlands Research School for Transport, Infrastructure and Logistics	Inter-Institutional	Private and Government, Funding agencies	Depends on the project	SET
Simula School of Research and Innovation AS, NW	PhD degree in Science	Private	Government, Funding agencies	Depends on the project	SET, BML

Source: EUA DOC-CAREERS Project

PACE - Paderborn Institute for Advanced Studies in Computer Science
CIFRE - Convention Industrielle de Formation par la Recherche
TEKES - Finnish Funding Agency for Technology and Innovation
CASE - Collaborative Awards for Science and Engineering

DOC-CAREERS Transferable Skills and Employment Case Studies

The following organisations provided free-form reports concerning transferable skills and/or employment issues of doctoral candidates and holders:

- EMBO (European Molecular Biology Organization)
- IDEA League (Imperial College London, Delft University of Technology, ETH Zurich, Aachen University RWTH), UK
- Ruhr-Universität Bochum, Germany
- Association Bernard Gregory, France
- CESAER (Conference of European Schools for Advanced Engineering Education and Research)
- Comunidad de Madrid, Spain
- Helmholtz Association, Germany
- NIFU STEP, Studies in Innovation, Research and Education, Norway
- UK GRAD Programme (now Vitae), UK

DOC-CAREERS Tracking Case Studies

The following universities and entities participated in the study on methodological aspects of tracking of doctorate holder careers (Table 2.1-2).

Table 2.1-2 Summary of DOC-CAREERS tracking case studies

Institution	Cohort	Subject area	Method	Survey point (after graduation)	Frequency
European Molecular Biology Organization, DE	EMBO postdoctoral fellows	Biological sciences	Cohort comparison	8-13 years	Every several years
European University Institute, IT	Institution	Social sciences	Tracking & Trends	10 years	Every five years
K.U. Leuven, BE	Institution	All	Trends	Exit survey	On-going
London School of Economics, UK	4 institutions	Social sciences	Ad-hoc survey	1-8 years	Pilot study
University Autonoma of Barcelona, ES	Institution	All	Single study	1 year	Pilot study
University of Ghent, BE	Institution (for pilot)	All	Trends	Exit	Pilot study
	Institution (for pilot)	All	Trends	During doctorate & exit	Pilot study (2-3 years)
University of Helsinki, FI	National	All	Single study	2-3 years	Pilot study
University of Jyväskylä, FI	9 institutions	All	Trends	2 years	Pilot study
Universiteit Utrecht, NL	4 institutions (for pilot)	All	Tracking	Exit, 3yrs, 5 yrs	Pilot Bi-annually
HESA, UK	National	All	Trends	6 –18 months	Annually
OECD	International (6 countries)	All	Trends	Total population	Pilot study (bi-annually)
Marie Curie Actions	International	All	Tracking	Total population	- -

Source: EUA DOC-CAREERS Project

2 The project and its European Dimension

2.3. The Enterprise Case Studies

The sample of large R&D-intensive companies was selected to achieve a balance in terms of i) innovation activity, ii) industrial sector, iii) sales volume and iv) geographical spread throughout Europe. EIRMA took the lead in the selection of companies amongst their membership, based upon available information. These companies have at least one R&D centre in Europe and were expected to have an interest in doctoral education. The list of interviewed companies is in Annex 7.1.

A distinctive feature of the selection of companies in DOC-CAREERS is that the measure of the innovation activity of the companies took account of both technological and non-technological innovation. EIRMA developed a version of an OECD methodology[35] to estimate an innovation index of its member companies (Annex 7.4.). According to this study, innovation activity can be classified in five types: Innovation Factor 1: New and diffused technology, plus training; Innovation Factor 2: Product and process innovation; Innovation Factor 3: Organisational structures/strategies; Innovation Factor 4: Protection related to design; Innovation Factor 5: Expenditure on design, marketing. The overall estimated innovation index is the result of the sum of the activity in these five factors. Based on the adapted methodology in DOC-CAREERS, an overall innovation index scale resulted from 1 to 14. This index is not a measure of the degree of innovation of a company but reflects the diversity of its technological and non-technological areas of innovation. A total score of 1 denotes relatively low innovation activity or innovation restricted to one single Factor, and a total score of 14 indicates relatively high innovation activity or innovation involving many Factors (Fig. 2.3-1).

The characteristics of the sample of companies were as follows:

i) Innovation profile: In general, selected companies innovating in technology, products and processes (Factors 1, 2 and 3), were quite active in protection related to design innovation (Factor 4) and less active in design and marketing innovation (Factor 5). The innovation profile of the companies is represented in Fig. 2.3-1 and reflects the balance on the overall innovation index. The sample included 10 enterprises with indexes ranging from 2 to 4; 8 with indexes between 5 and 9; 11 with innovation indexes between 10 and 14. The 29 companies all innovate in Factors 1 and 2 - in broad terms technology, products and processes; 22 companies innovate in Factor 3 - organisational structures and strategies; 15 companies innovate in Factor 4 - protection related to design; and 9 innovate in Factor 5 - design and marketing.

Their ways and means to innovation included in-house R&D, acquired external knowledge, design, corporate strategy and marketing strategy (Section 4.2). These companies based in 14 European countries employed doctorate holders and/or offered their views on doctoral education.

ii) Industrial sectors represented: Aerospace (1); Automotive (1); Chemicals (4); Construction (1); Electronics (1); Energy (2); Engineering (2); Food (1); Forestry/Paper (2); Health, Personal Care, Biotechnology (7); Information Technologies (3); Metals (4) and Telecommunications (2).

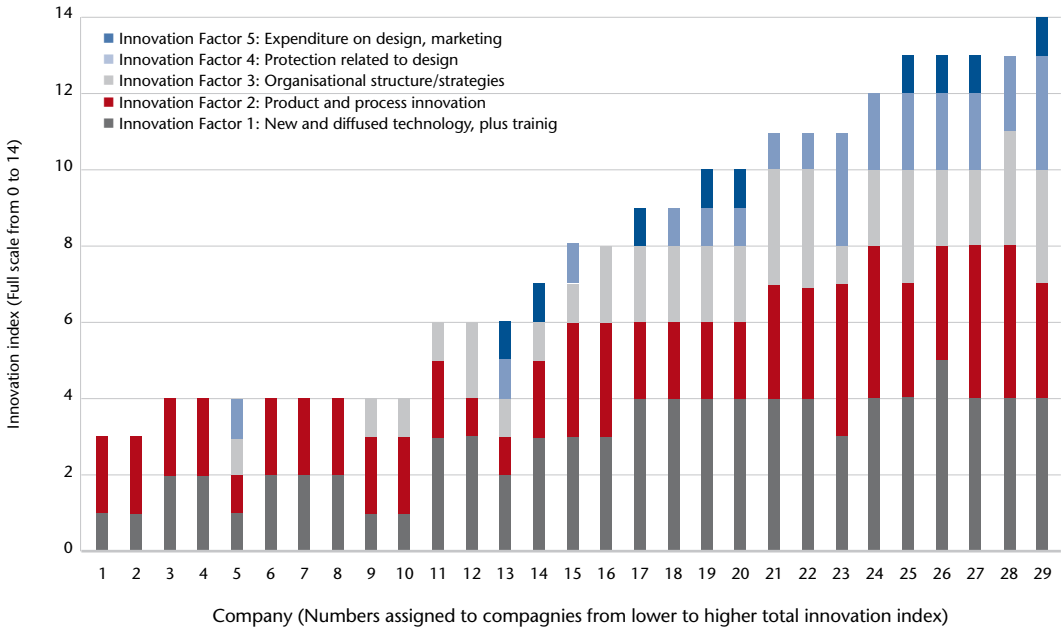
iii) Sales volume: from 0.2 to 81.3 billion[36] Euro in 2007 (Fig. 2.3-2).

iv) Location of interviewed R&D centers: Austria; Belgium; Czech Republic; Denmark; Finland; France; Germany; The Netherlands; Sweden; Switzerland; Turkey; UK and USA (Fig. 2.1-2).

v) Staff proportion of doctorate holders: basically all companies employed doctorate holders, especially in their R&D departments, and their proportion widely ranged from 0.5% to 70% of the R&D staff.

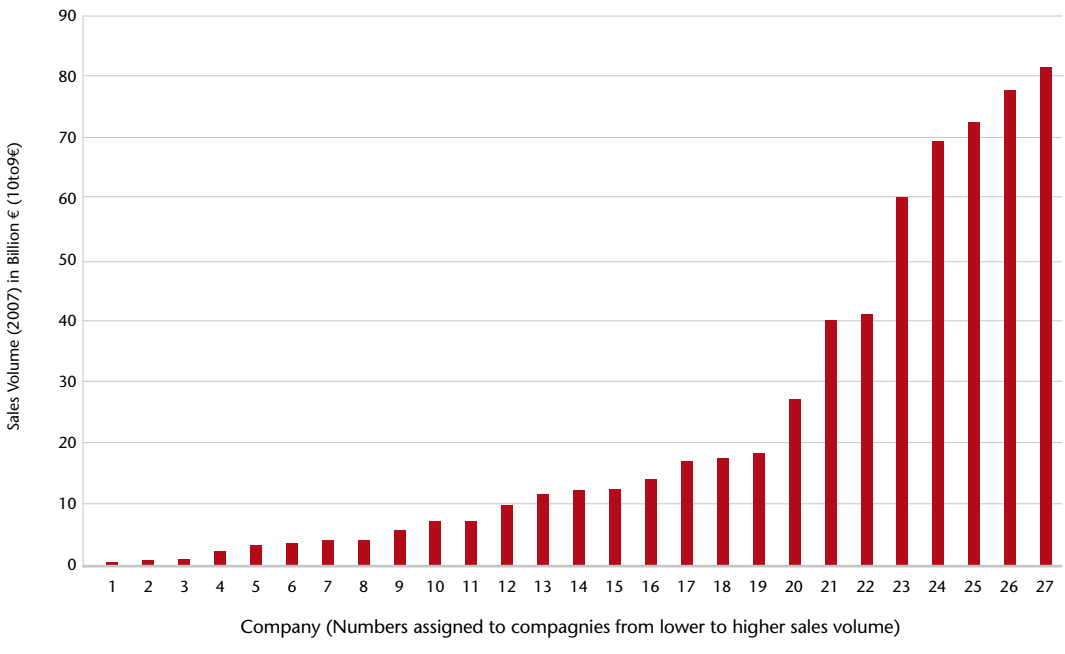
35. The innovation factor was calculated based on a methodology developed by OECD: "Indicators of Non-Technological Innovation", DSTI/EAS/STP/NESTI (2007)17, 04-Jun-2007.
36. 1 Billion = 1,000 Million

Fig. 2.3-1 Innovation profile of interviewed companies*



** Data available for 29 enterprises. Source: EIRMA*

Fig. 2.3-2. Sales volume (2007) of interviewed companies*



** Data available for 27 enterprises. Source: EIRMA*

3 Doctoral Programmes in Cooperation with Industry: Contexts, Trends and Strategies

In this chapter, the analysis of the university case studies (Table 2.2-1) and interviews conducted with enterprises (list in Annex 7.1.) focus upon the contexts, trends and strategies underlying the development of collaborative doctoral programmes. Empirical findings are reported both as common trends and perspectives and as individual view points from enterprises, universities and doctoral candidates.

DOC-CAREERS cases revealed a myriad of particular initiatives, reasons, benefits and challenges to engage in collaborative doctoral education reflecting a variety of foci and views within several generic trends and characteristics.

3.1. Collaborative Doctoral Programmes in the Context of University-Industry Cooperation

In general, it seems that long-term university-business collaboration schemes usually have a better chance to succeed than short-term initiatives. One reason is that universities can better deliver in the long term. Another is that long-term collaborations tend to reflect a mature relationship, which has been well-managed on both sides. These general statements were confirmed by all the different inputs to DOC-CAREERS. The university and industry case studies showed a range of principal collaborative initiatives in which universities and industries play, in the broadest sense, different roles in different timeframes (Figure 3.1-1).

At one extreme of the role axis, the university is strictly a supplier of knowledge and human resources for the industry by performing research within limited contracts with specific projects. This interaction does not necessarily entail strong and durable relations between the two entities; however it can be seen by the partners as providing the first steps towards future longer-term relations, as trust builds between them.

In specific contract research we can distinguish two strategies:

i) Outsourcing: The company outsources the conduct of a research project, or a part of it, for which they seek knowledge and expertise that is not available in the company. Normally, the contracted university has a good reputation in the relevant field. Most of the interviewed companies use this sort of collaboration frequently with one or more university partners.

ii) Partnership: A company and a university sign a contract to work together on a specific project where the university and company provide different specialist knowledge and the company contributes towards scientific-technical development. This type of contract can be used as a tool to test interaction between the partners and eventually evolve to longer-term or regular collaboration.

At the other extreme of the role axis, universities and industries are partners which carry out research activities and jointly contribute to taking part in education and training. In this "partner" role, strategies are considered by the companies as an investment for the future and are usually seen as long term. Universities see this type of interaction as one way to enhance employability of their graduates and attract resources from industry for research. The DOC-CAREERS university and industry case studies have illustrated the following types of collaboration:

i) Doctoral Projects/Programmes: Collaborative Doctoral Programmes involving industry and university are a good vehicle to enhance knowledge transfer, intersectoral mobility and mutual understanding. Doctoral programmes enable companies to take part in researchers' education and training, exposing

them to environments which will allow candidates to acquire skills relevant to the business world in addition to those relevant to the academic world. This report deals primarily with the issues related to this type of collaboration.

ii) Short-term internships: In this type of initiative companies play a role in bachelor or master programmes by hosting students for a certain period of time. This allows them to experience business environments before looking for a job in the labour market and, indeed, the company may see the student as a potential employee. Parent universities may or may not have been involved in previous collaborations with the company and it is normal to start with short-term collaboration when the partners do not know each other very well. In this sense, the internee can be considered as a seed link between the university and the company.

iii) Short-term secondments for academics in the firm or vice-versa: in a similar way as the student internships, academics can be hosted by the company to work in corporate research teams. It also works the other way, when corporate researchers are hosted by universities or academic laboratories as a short-term researchers and/or professors. Normally, these secondments take place when the company and the university have learned to rely on each other based on a solid previous relationship. Regardless of the duration of the individual secondments, this strategy tends to be long-term oriented and does not necessarily focus on a specific project but more on a broad research field.

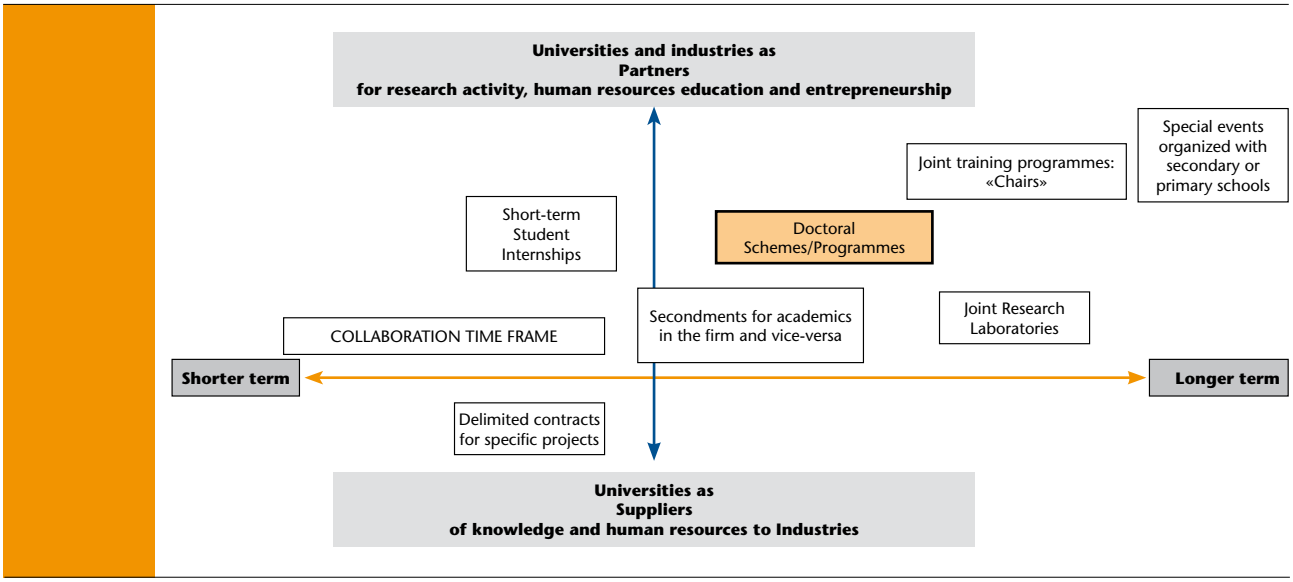
iv) Joint Research Laboratories: A company and a university or laboratory can jointly decide to set up what is called a "laboratory" to work on themes of common interest. These laboratories are not necessarily related to one specific project and can be located in the company or in the university. In general, these laboratories are created as a result of a successful previously-established partnership and developed with a long term perspective.

v) Joint Training Programmes ("Chairs"): These are programmes developed jointly by universities and enterprises around a specific topic. The main objective of companies in setting up Chairs in collaboration with universities is mainly to educate people who can be potential employees and who have a skill profile most suitable for the company activities. These Chairs are created as a result of an earlier successful partnership and take a long term perspective.

vi) Special events in secondary and primary schools: These events are organised with a forward-looking perspective with a very specific objective: to show young people a glimpse of how science relates to the world of business by organising attractive events that awaken their awareness and encourage their interest in scientific and engineering careers. This kind of initiative responds to the general concern that Europe will face, in the medium to long term, a shortage of high-skilled people in scientific and engineering fields. The latter is anticipated as active professionals retire, and current generations of students choose fields of employment considered less difficult or more attractive than sciences and engineering. This early-age event strategy is one way companies try to anticipate and correct the situation.

3 Doctoral Programmes in Cooperation with Industry: Contexts, Trends and Strategies

Fig. 3.1-1 University-industry collaborations: Roles of partners and timeframe



Source: EUA DOC-CAREERS Project

As indicated above, Collaborative Doctoral Programmes are one way to strengthen university-industry links. In the past, in general, companies had fewer opportunities to intervene in students' curricula. Nowadays, companies can become legal actors in doctoral programmes as well as in other levels of higher education (e.g. sponsored Chairs, Joint Training Programmes and so on). In the next sections of this chapter, DOC-CAREERS case studies illustrate how companies are becoming more engaged in the education and training of highly-skilled professionals in ways which are 'win-win' situations. The following sections address the added values of collaborative doctoral education in relation to traditional university-centred doctoral education, the motivations, challenges and benefits of each partner, the characteristics of the programmes, the role of the doctoral candidate, the basic elements for successful collaborative doctoral programmes and the impact and sustainability of these sorts of initiatives.

3.2. Objectives of Collaborative Doctoral Programmes and the Basic Conditions for Success

Doctoral education has one very clear objective: a doctoral candidate will obtain a doctoral degree by performing original research within academic standards following an examination by a committee of experts[37]. Currently, this process normally takes 3 to 5 years. As universities are the institutions that grant the doctoral degrees, the ultimate responsibility for doctoral education clearly lies with them. This responsibility applies fully also to collaborative doctoral programmes, even when a company is formally recognised as a partner in the doctoral process (and indeed the objective and responsibility are generally not questioned by the partner company).

What is unique about collaborative doctoral education?

For the purpose of understanding the distinctive characteristics of collaborative doctoral programmes, we can discern three main categories of doctoral programmes vis-à-vis the involvement of industry:

[37] http://www.eua.be/fileadmin/user_upload/files/Nice_doctorates_seminar/final_recommendations_in_EUAtemplate.pdf

i) Doctoral programmes with no involvement of industry: These are the classic university-based doctoral programmes in any field of knowledge. Historically, universities educated doctorate holders using the classic supervisor-supervisee model, without involving industry at all.

This classic tandem is nowadays evolving toward more open models, such as enlarging the supervisory team with other researchers or career development experts or involving external experts in the examinations' committees.

ii) Doctoral programmes with limited involvement of industry: These are often classic doctoral programmes involving indirect input from industry but little direct contact with the doctoral candidate, for example when the candidate is involved in contract research, especially in SET and BML areas. In this category of doctoral programmes the industry contribution may include funding, data for research purposes and even specific fit-for-purpose placements, but with little interaction with the doctoral candidate.

iii) Collaborative Doctoral Programmes[38]: These programmes involve close interaction between a company, a doctoral candidate and, of course, a university. A distinctive characteristic is that industry experts take part in the supervisory committee, officially or informally. The company can play several roles, but its participation in the candidate's supervisory committee is what effectively reflects the specific nature of the programme (Section 3.4.1). Indeed, the role of industry is officially recognised and encouraged in the CIFRE, CASE and Danish Industrial PhD Programmes and Marie Curie Actions.

Collaborative Doctoral Projects: These are doctoral theses carried out with interaction between a university, a company and a dotoral candidate. A distinctive characteristic is that industry experts take part in the supervisory committee, officially or informally. Industry can play several roles, but being in the supervisory committee is what effectively reflects the specific nature of the collaborative doctoral project.

As noted earlier, some of these programmes have a long-established tradition (e.g UK CASE Awards have been offered for more than thirty years). More and deeper involvement of industry in doctoral education is being fostered within the framework of the Open Innovation Model[39] which many companies are progressively embracing. The active implication of industry modifies, at least in principle, the more traditional doctoral process, by incorporating a new group of actors, factors and values. The specific contributions from industry may include funding and providing research data, but also structured placements, supervision, additional business training, and facilitating networking outside academia (Section 3.4). In this context, structured placements are periods of internship of doctoral candidates in business premises where they have the opportunity to perform their research while experiencing the "life" of the company. Placements are seen as one of the most important contributions that an industry can offer to the education of a doctorate holder wishing to gain insight into the business world (e.g. from using business labs and participating in business meetings to having lunch in the canteen). How much a doctoral candidate can embed in the daily life of the company will depend on company policy but the sole fact of being exposed to the industrial dynamics is already a learning experience of itself.

There is also widespread agreement that many, if not all, of the standards of academic research will continue to apply when developing doctoral projects with industry. Candidates must receive degrees of known quality in an allocated and reasonable timeframe. For them, the advantage of a collaborative doctoral experience is that, in addition to sound research skills, they will gain an understanding of the business world which can facilitate communication with industry and ultimately broaden their employability perspectives, outside academic environments. In general, practitioners across disciplines involved in collaborative doctoral projects had

[38] For the purpose of the discussions in this project the term 'programme' in this collaborative category has a broad meaning, indicating effective and on-going university-business interaction involving doctoral candidates, with and without an official label.

[39] Open Innovation expresses the ambition to make greater productive use of knowledge, technologies and similar resources available outside the company, in order to augment the company's own resources. While most "open innovation" activities involve company-to-company relationships, the philosophy also emphasizes relationships with universities and public research organizations.

3 Doctoral Programmes in Cooperation with Industry: Contexts, Trends and Strategies

similar views on what are the added values, risks and main outcomes of these sorts of initiatives (Table 3.2-1).

The **added values** of collaborative doctoral research are consequences of the 'exposure' of doctoral candidates and university research to the business environment. The role of industries varies with the discipline. Normally, in SET or BML areas, businesses tend to be more deeply involved than in ESS (Section 3.4.2). The exposure allows the candidate to gain a unique insight into non-academic organisations from a researcher perspective which, when properly handled, can be beneficial for all partners in the long term: the university research unit, doctorate candidate/holder and industry. In practice, some of the distinctive outcomes of collaborative doctoral research include, for example: becoming aware of market time pressures and the whole process 'from ideas to markets'; taking account of budget restrictions, specific market regulations (e.g. directives) and other legal frameworks (e.g. Intellectual Property Rights -IPR); involving industry leaders in supervision; accessing additional industry training.

Although the potential benefits are widely appreciated by successful practitioners there are equally some potential concerns that universities and companies should be aware of when establishing partnerships in doctoral education.

The **risks and concerns** normally relate to misunderstanding and/or mismanagement of the doctoral process by either partner. There may be an excessive focus on non-academic research activities, inadequate management of the dynamics of the collaboration (e.g. the ratio of time spent in business/university) or unresolved conflicts over IPR issues (Section 3.4.1). A concern, remarked by some, even when everything else has been properly addressed, is that the candidate's thinking and creativity may be unduly restricted by the pre-established boundaries of the project, for example thereby missing opportunities for breakthrough discoveries. However, Olivier Peyret, Schlumberger, valued the dual supervision because it enabled new ideas to be generated from both university and business perspectives.

It is fair to comment that both the benefits and the risks and concerns can be over-stated, and that each can be managed to obtain the desired outcomes. Indeed an objective of this project has been to cast light on how this can be achieved.

Main **outcomes** in terms of qualifications of doctorate holders are that they gain an understanding of the role of research beyond the academic world and hence they are better prepared for employment in industry and for establishing better links with it if employed elsewhere. Companies regard collaborative doctoral programmes as a genuine part of developing stronger relations with universities and may perceive that doctorate holders educated between and by the two worlds are better prepared to fit in corporate positions than doctorate holders educated exclusively in a university environment. It is common in companies that have large R&D resources that the close contacts between the candidate and the company during the doctoral process improves the candidate's subsequent chances of employment with that company (e.g. Arcelor Mittal, Lafarge).

> *"Candidates who spent most of their time at Lafarge research centre can be hired before they have obtained their PhD degree. It fits very well because the candidate is involved in company projects. When they earn their PhD degree their wages are reconsidered and levelled to other researchers. Employment opportunities for doctoral candidates who did their PhD exclusively at the university are much lower."*
>
> Paul Acker, Lafarge

Table 3.2-1 Collaborative doctoral thesis - general points

Added values:
- Quality of research: academic standards with strategic value for industry
- Insight of both academic and non-academic organizations
- Broadening employability perspectives for doctorate holders by learning to apply skills and knowledge acquired through research in industry (skills & knowledge transfer)
- Reinforcing university-business cooperation: joint supervision, mutual access to academic and business networks, etc.

Outcomes:
- Doctoral graduates with a better understanding of the industrial world
- Doctoral graduates better prepared for employment outside academia
- More and better links between university and industry

Concerns:
- Excessive focus on non-academic activities
- Limiting freedom for the development of break-through ideas
- Conflict on publication rights, intellectual property rights
- Supervisory scheme: communication issues, quality

Solutions:
- Committing resources: material - access to necessary equipment; human - supervisors, doctoral candidate, others if necessary
- Realistic expectations from all sides: project fitting into both academic and business research fields and strategies, awareness of the nature of the doctoral process, time-frames, needs, expected outcomes, work load, etc.
- Formalisation of an agreement and flexibility to accommodate to unforeseen situations

Source: EUA DOC-CAREERS Project

Basic Conditions for Successful Collaborative Doctoral Programmes

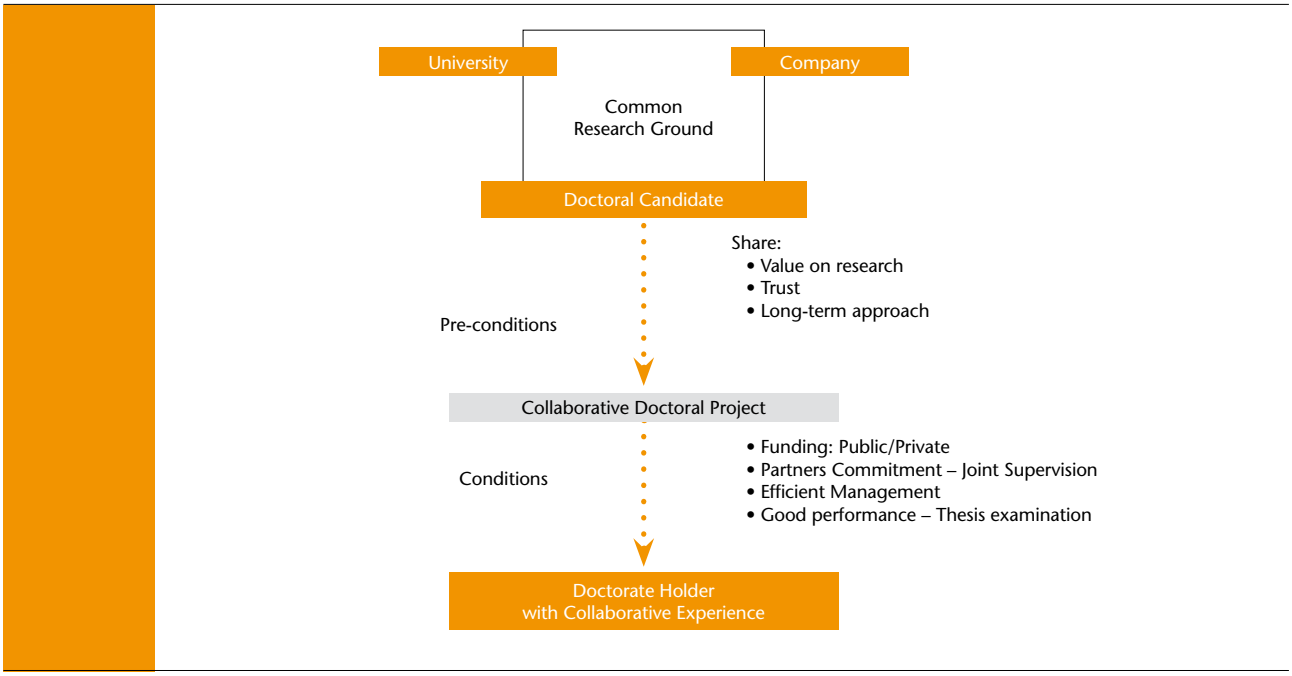
The stakeholders in a collaborative doctoral project, including the university and industrial supervisors and the doctoral candidate, have to integrate and operate with different goals and cultures and their relations are not linear. However, the process towards earning the doctoral degree is indeed linear and all actors involved should be clearly aware of its objectives and boundaries to minimise risks of e.g. failure, unreasonable workload or inadequate managament of IP Rights.

There are some basic conditions that establish firm ground on which to take doctoral projects forward with reasonable prospects for success. Fig. 3.2-1 summarises the essential pre-conditions to set up a collaborative doctoral project and the conditions to take it forward successfully. The dotted arrows are there to indicate that the process is not always straightforward. As **pre-conditions**, partners need to: i) value the background knowledge they bring to each other and the knowledge they think will be generated during the doctoral research; ii) share mutual trust; iii) adopt a sufficiently long-term approach towards research collaboration. For the university and doctoral candidate, this means allowing 3 to 5 years to earn the doctoral degree which needs to be compatible with the interests of the company for optimal partnership relations. This last pre-condition for partnership is linked, especially for industry, to their development perspectives within their socio-economic contexts. Historically, universities tend to have a long-term perspective based on their established existence. The continued existence of individual firms is much more dependent on the economic enviroment. However, all successful approaches are based on mutual trust and understanding, and not on an expectation that one party should contribute to another's objectives.

3 Doctoral Programmes in Cooperation with Industry: Contexts, Trends and Strategies

A clear trend in doctoral education in last 10-15 years in Europe is the increase of organised or structured approaches between university and industry in many fields of knowledge, especially in SET and BML areas, but also in ESS. Many of the structured initiatives studied in DOC-CAREERS started during the years 1990 to 2005, with the exception of the CIFRE Programme, UK CASE Studentships and a few others which started before. Structured initiatives of university-industry cooperation may be generated by universities, industries, governments or as joint collaborations. Each doctoral project is unique and the committed partners may have very diverse needs, economic perspectives and expectations of collaborative research, even within the same field of work. The main advantage of organised approaches, regardless of the area of knowledge, is that they provide frameworks which set boundaries, define strategies and refine them based on lessons learned from previous experiences. Practitioners strongly remarked that successes, however, only come with a sound understanding of the process, concerted efforts, trust, commitment and effective communication. These characteristics conform to the four basic **conditions** for the partners to engage in Collaborative Doctoral Programmes namely i) funding, ii) joint supervision of the doctoral candidate, iii) efficient management and iv) good performance in research which will eventually lead to a doctoral degree gained according to established academic standards.

Fig. 3.2-1 Pre-conditions and conditions for collaborative doctoral projects



Source: EUA DOC-CAREERS Project

These basic pre-conditions and conditions are simple to state but very complex to build and manage. The rest of this chapter addresses how it can be done by drawing on experience from DOC-CAREERS case studies of collaborative doctoral projects and programmes.

3.3. Setting up University-Industry Collaborative Doctoral Programmes

As the benefits for all partners become more visible, Collaborative Doctoral Programmes are increasingly seen as a genuine way to strengthen university-business ties in research and innovation. In this respect, many companies, universities and governments are developing concerted, organised actions in the form of strategic plans, policies and funding schemes to foster and nurture collaborative R&D. However, no matter what the level of structure in the collaborative doctoral programme, collaboration in doctoral education is normally established on the basis of successful previous research initiatives involving the partners.

3.3.1. Types of Initiatives, Drivers and Funding Sources

DOC-CAREERS cases demonstrated that any stakeholder can take the initiative to set up a doctoral project in cooperation with industry, e.g. a professor, an employee in a company, a university as institution, a student. It is common that companies which have clearly identified research topics of interest seek the expertise of universities after confirming that this is their best option. Some leave the university to select the candidates. Depending on company policy and their particular situation, companies may co-determine research topics and select candidates together with the university. Some universities pointed out that companies approach them because they have identified an academic and/or a doctoral candidate as a potential partner (e.g. UPMC, ESADE) and they can even give the responsibility to the university to turn the idea into an application or project (e.g. Newcastle). A surprising case was that reported by Mykolas Romeris, whereby some enterprises in the ESS area approached the university because they were interested in providing doctoral education for some of their employees. Companies which have established regular relations with universities, and vice versa, adopt a "give and take" approach towards initiating doctoral projects. As, for example, Synpo remarked: "There is no rule: it depends. Sometimes it is us, sometimes it is for the university to suggest a candidate to us".

Examples from the Case Studies: Who started it?

- Faculty staff, such as single or a group of professors, researchers or doctoral programme coordinator (e.g. Masaryk; Paderborn; Bangor; Matej Bel; ESADE; Newcastle; UPMC; Cagliari; Simula; TU Delft; IBM).
- The Rector and/or Vice Rector/s in collaboration with faculty staff (e.g. Athens, Hanken).
- A member of the university administration or body, in collaboration with faculty staff, such as the head of department of doctoral studies, the head of the international department of graduate schools, the research transfer office (e.g. Mykolas Romeris; Paderborn; Bangor; Simula).
- A Bachelor/Master graduate working in a company identified a subject appropriate for a doctoral project (e.g. UPMC; Athens; IBM).
- The industry: in interviewed companies the initiative had been taken at various levels (e.g. Corus; Novo Nordisk; Arcelik; IBM; Arcelik; Biocydex; Philips (Van der Pol Programme); The Collert Foundation (from Hanken); Solvay; Arcelor; Lafarge; UPMC; ESADE; Newcastle).
- Both the university and the industry (e.g. Haldor Topsoe; Stora Enso; Synpo).

Source: EUA DOC-CAREERS Project

3 Doctoral Programmes in Cooperation with Industry: Contexts, Trends and Strategies

Once the seed of an idea is planted it is the combination of motivations, capacities and efforts of the stakeholders involved that will turn this idea into a realistic doctoral project. For example, a Master graduate with an idea to develop may not have the capacity to take it forward without appropriate academic and industrial contacts and resources. In taking forward the initial idea, five main types of initiatives were identified: individually-driven, university-driven, industry-driven, government-driven and jointly-driven. A summary of the types of the initiatives and their characteristics appears in Table 3.3-1. An explanation of each of the types and related examples from DOC-CAREERS cases follow:

- **Individually-driven initiative:** this is the more traditional type, where a person from faculty staff (professor, research staff, leader of a research team, etc.) and a person from industry agree to conduct research projects of mutual interest. In this type of initiative, the university and the company do not need to have a particular strategy on research and innovation or in doctoral education. If the research is undertaken in areas of basic research where there are no particular issues associated with IPR, and partners agree on the funding conditions, the project can easily be conducted with the approval of the parent organisations. Essentially, a project just has to fit the research areas or expertise of the professors/researchers with the interests, or strategy, of the business.

  An individual professor interested in developing relations with industry can also be motivated by other drivers such as contributing to raising the profile of the university, enhancing the employability of doctoral holders and ultimately making a contribution to society as a whole. A Bachelor or Master graduate can be the instigator of doctoral cooperation with a company based on ideas they would like to develop and that fits with the company's interests. Another main driver for the doctoral candidate, in addition to strong interest in a research project itself, is the improvement of employability prospects after earning the doctoral degree. (e.g. ERIM, Masaryk, Cagliari, Upsala, Matej Bel, Hanken).

  The characteristics and motivations for individually-driven initiatives are crucially important for all the other types of organised initiatives which follow because, no matter how structured the programmes, one-to-one interaction is the basis for their successful development.

- **University-driven initiative:** this type of initiative can be developed by a faculty, a research unit, department, graduate school, or by one (or more) universities. In such cases, universities make use of their autonomy to establish areas of research priority and develop collaborative schemes with industry. The main drivers of this type of initiative can be multiple, including incorporating industry R&D in their research, raising the institutional profile, being willing to enhance the employability perspectives of their doctoral graduates or, in general, aiming at enhancing their contribution to society. They may formulate their plans within or without larger policy frameworks, depending on the funding opportunities in the field and their strategic choices. Usually, this kind of initiative is based on a critical mass of university professors and researchers with good contacts with businesses or ready to develop new relations. Funding sources are usually a mixture of support from the corporate world, competitive public funding schemes and the mobilisation of government resources for the larger initiatives.

Examples from the Case Studies: University-driven initiatives

- Doctoral projects on management of science and technology at Athens University aim at educating highly skilled individuals in identified areas where there is a need, or expected need, for expertise in the future. This was done within the policy framework of the PENED programme.
- Mykolas Romeris University decided to respond to national strategic plans to foster knowledge-based economies, even though their main areas of research (ESS) were not a national research priority with no public support.
- TU Delft decided to set up the TRAIL initiative, partnering with three other universities at departmental level in order to secure a better position for their graduates in the labour market and to strengthen their external funding stream. The main "trigger", therefore, was internal and not funded by external sources, although their doctoral candidates were.
- Paderborn University has a long standing tradition in cooperating with companies in research and education, independently of regional policy initiatives available.
- Others initiatives organised by departments, professors, doctoral candidates themselves, various national and international networks were reported by ERIM, Aarhus, Masaryk and ESADE.

Source: EUA DOC-CAREERS Project

- **Industry-driven initiative, from large industry or SMEs:** in this type of initiative a company or group of companies which value university research seek university professors/teams to develop specific projects in order to gain access to scientific knowledge and human resources that can help them in maintaining and enhancing their competitiveness in the market. Industry-driven cooperation with universities normally follows specific strategic medium to long-term plans to develop new knowledge on which they expect either to increase their innovative capacity with respect to their products, services, etc., or merely to test early-stage methods and technologies or solve technical challenges. Intensive R&D companies, large or SME, tend to seek top expertise in their fields of interest first in their region, if available, but also worldwide. Companies may use available public funds to share the costs of these projects (through competitive funding schemes or by mobilising government resources), or set up programmes using their own funds, which allows them to take part in the selection of the doctoral candidate and establish their own particular IPR regime. This is the case, for example, of the Philips-Van der Pol Programme (some of their doctoral candidates are also funded by public schemes) and the "IBM Ph.D. Fellowship Awards".

  Initiatives driven by large companies are normally well-organised, with a long-term vision based on clear research strategies. These companies tend to build cooperation with universities they know well from previous successful projects but also with new university partners that have a world reputation in their fields of interest. Initiatives driven by SMEs tend to have a stronger sectorial and/or regional approach and are more frequently supported by public funds (e.g. national schemes or EC Structural Funds).

Examples from the Case Studies: Industry-driven initiatives

- *Corus* board members "decided 15 years ago that they needed a long-term vision to develop innovation in their areas. They sought partners with the same interests and explained their needs to the local government, proposing to set up a scheme for cooperation with 50% government funding".
- *Dow Corning*, a knowledge-driven silicon chemistry company, centralises its research in the USA and carries it out in cooperation with universities in the UK, Japan and Russia among others. "We go wherever the knowledge lies", said Janet Blackely.
- *IBM* works in close contact with the region and its universities: "It is very important that people have the chance to join an industry during their PhD".
- *Philips:* "We have our own general guidelines for cooperation and adjust them to local characteristics (e.g. depending on the EU member State)", said P. Aarts and L. Appelo.
- French companies, such as Renault, Lafarge and Biocydex take part in 'Poles de Competivité' and use the CIFRE programme widely.
- SME-intensive R&D companies work normally with local/regional universities, physical proximity being an essential factor for successful cooperation (e.g. Oridis Biomed).

Source: EUA DOC-CAREERS Project

3 Doctoral Programmes in Cooperation with Industry: Contexts, Trends and Strategies

- **Government-driven initiative:** Regional, National and European governments and other Public Research Funding Agencies are constantly developing and updating strategic plans driven by an overall goal to increase economic competitiveness based on knowledge creation. These plans usually include competitive funding schemes to encourage and support the industrial base in investing in research and innovation. Plans take into account their broader policy frameworks in establishing priority research areas, e.g. regional plans take account of national and EU strategies; national strategies take account of EU and other global strategies. In recent years, many strategic plans have also started supporting collaborative doctoral education for the better preparation and integration of needed professionals into the labour market. With the exception of large companies that may have their own doctoral programmes with no public funding, the majority receive support from a public body, either local, regional, national or European.

Examples from the Case Studies: Government-driven initiatives

- Regional/Local Policies: ESADE benefits from Catalan Government funds through public funding agency AGAUR; Padernborn benefited from the federal state North Rhine-Westphalia which founded six Graduate Schools in 2001.
- National Policies: Athens received support from the Greek General Secretariat of Research and Technology (Ministry of Development and Ministry of Education), EOMMEX (institution that supports research regarding the support, development and sustainability of SMEs; ESADE from the Mininisterio de Educación y Ciencia in Spain; Newcastle from CASE Programme and the UK Research Councils; Masaryk University from the Czech Ministry of Education and the Czech Ministry of Industry and Trade; Aarhus from the Industrial PhD Programme in Denmark.
- European Policies: Marie Curie Actions and the European Social Fund are an important source of funding to establish cooperation with industry in doctoral education. This is the case of, for example, Mykolas Romeris University, Lithuania, in the field of social sciences, where they use of these funds as a first stage of a process that aims to create a system where industry participates actively in doctoral education. Their recently created Doctoral School of Social Sciences is a basic instrument for cooperation. Another university using European Social Funds to increase their competiveness of a remote region is Bangor University, UK.

Source: EUA DOC-CAREERS Project

- **Jointly-driven initiative:** These involve a combination of two or more initiatives of the type described above. Case studies provided by Hanken (with its CERS and CEFIR Competence Centres), the TEKES scheme, Newcastle-CASE and Simula are examples of this. Encouraged by policies fostering innovation and the generation of cutting-edge knowledge, universities may decide to join in such coordinated efforts, for example, to respond better to technical demands in their fields of expertise, to increase the competitiveness of their research, and to contribute to raising the profile of their institutions and regional/national innovation capacity. For example, the Simula Research Laboratory was created in 2001 based on a national research policy that agreed upon the necessity to strengthen IT as a research area in Norway. The initiative was supported politically, administratively and financially by stakeholders in industry, politicians and administrations at different levels, from national to local.

Table 3.3-1 Outline of initiatives in collaborative doctoral programmes and their main characteristics

Initiative	Initiated by …	Framework Drivers	Primary level of engagement
Individually-driven	Faculty member, professor, company employee, Bachelor/ Master graduate	Research Employability	Individual (with approval from partner organisations)
University-driven	A group of faculty members, a Rector, Vice Rector/s, a member of the administration, knowledge transfer body, groups of universities	Research Institutional profile – quality of doctoral education Employability of graduates Contribution to society	Organisational – relevant level (with commitment and support from individual professors, researchers, managers, etc.)
Industry-driven	CEO, Company Board, groups of companies	Access to Knowledge Access to Human Resources Business Competitiveness	
Government-driven	Local/Regional/National/EU Government Bodies and Agencies	Economic Development Social Benefit	
Jointly-driven	Any combination of the above	Synergy of drivers from partners	

Source: EUA DOC-CAREERS Project

When establishing a collaborative doctoral project or programme universities and industries can face many obstacles and challenges to take forward the collaboration. Large doses of goodwill, perseverance and patience are needed to go through the dynamics of the triangle relationship - university, company, doctoral candidate - in which each partner has its own values, culture, motivations, interests, time frames, and expected benefits. Based on the input of the DOC-CAREERS case studies, the following sections explore main motivations from each of the three points of view, the potential benefits and the challenges in establishing the partnership and in taking it forward. Section 3.6. provides recommendations offered by the practitioners on how to improve the dynamics of collaborative doctoral project development.

3.3.2. Motivations and Benefits

DOC-CAREERS cases demonstrated a variety of particular motivations, and these can be clustered according to several generic characteristics. The characteristics are listed in Table 3.3-2 and the paragraphs that follow demonstrate the range of views through providing examples.

Motivations

Motivations cited by universities, industries and doctoral candidates to engage in collaborative doctoral programmes were quite uniform in each partner community:

Each **university** case study mentioned one or more of the following:

i) Exposure to wider research environments
ii) Improving the quality of doctoral education and institutional reputation
iii) Enhancing employability perspectives of doctorate holders and their social status
iv) Responding to the growing industrial demand for access to generated new knowledge
v) Attracting more diversified funding from external organisations for research
vi) Better integration in the European Research Area (ERA)
vii) Stimulating university-industry dialogue.

On their part, **industries** indicated clearly two motivations which they saw as contributing to the more general objective of enhancing their competitiveness:

i) Access to cutting-edge research
ii) Access to a highly qualified work force.

Doctoral candidates specified one or more of the following motivations:

i) Gaining insight into non-academic sectors
ii) Address "real life" research problems
iii) Enhancing employability opportunities, especially outside academia
iv) Opportunity to build up a network of contacts outside academia
v) Ready-made ("jump in work") projects. This latter point was made by doctoral candidates who had been in employment before starting doctoral education.

3 Doctoral Programmes in Cooperation with Industry: Contexts, Trends and Strategies

Examples from the Case Studies: Motivations

- *TU Delft*: "We had several motivations: 1) TRAIL's partners desired to be more involved in academic research at universities. 2) The universities felt the need to forge stronger relationships with the 'practical', non-academic world. 3) The establishment of TRAIL enabled joint participation in national research programmes, and hence allowed more subsidies to be secured and more doctoral candidates to be appointed."
- *IBM-Switzerland*: "It is a way to hire excellent permanent people. We contribute largely to the Swiss economy. Both sides have interests in these collaborations because those who wish to go back to university find that universities welcome their experience in industry."
- *Newcastle – Doctoral Candidate:* "The subject was not something I knew anything about but after some initial research (before applying) I was hooked and wanted to know more. Because it was a CASE studentship I felt that there would be a practical experience element that would be useful when finding future employment."

Source: EUA DOC-CAREERS Project

Benefits

Universities had a range of specific benefits to report from collaborations which can be clustered into the following kinds:

- **Promoting innovation, entrepreneurship and social responsibility:**
  i) The opportunity to directly benefit from the corporate world
  ii) The opportunity to build more and better relationships and partnerships with the corporate world, especially in knowledge-intensive sectors, e.g. by sharing resources and facilities, jointly developing new technologies of interest to companies, accessing academic laboratories and specific data, etc.
  iii) Stimulate non-academic organisations' interest in collaboration with the university (e.g., companies which may be reluctant to risk investment in large, costly research projects, may be persuaded that short-term placements provide an opportunity to test the value of collaborative research for a relatively modest outlay)
  iv) Access to conferences and professional networks in specialised sectors or research topics.

- **Incorporating industry input within university research:**
  i) Possibility of developing new fields of research, increase interdisciplinarity and find topics for doctoral theses involving research that could be more oriented towards industry needs
  ii) Include professionals from industry in supervisory teams
  iii) Use real data from external partners as case studies for doctoral research
  iv) Enhance role of universities in regional innovation, as new abilities and talents settle in the region.

- **Gain awareness of technical challenges facing companies:** there is a general feeling of getting in touch with the problems of the "real world", and specifically gaining knowledge of the corporate world's current issues of interest, technological needs and practical know-how, which would otherwise be difficult to achieve.

- **Providing highly qualified workers for the labour market:** universities judge that doctorate holders who have participated in collaborative research during their doctoral studies have more opportunities of employment in non-academic organisations because they have a greater awareness of the business world and are better prepared to use their transferable skills. However, some academics also found these graduates valuable in academic positions where experience in industry is an asset, especially because they can be a good interface between the two worlds and can link theoretical knowledge and practice more easily.

- **Contributing to sustainable funding for research and research infrastructure:** this category of benefits included:
  i) Acquiring and updating equipment, research facilities, infrastructure
  ii) Recruiting doctoral candidates, post-docs and researchers in general
  iii) Enhancing PhD candidates' entitlements (e.g. participation in conferences, building networks, etc.).

- **Enhancing quality of research management:** universities reported that they need to adapt their internal processes of decision making and management to respond better to the normally faster processes used in industry. Some indicated also that it was beneficial for the institution because they had to clarify their IPR policy.

Interviewed **companies** with experience in collaborative research with universities had quite uniform views on the benefits, which can be summarised as follows:

i) Bringing in access to a highly qualified work force and know-how (e.g. employment, outsourcing research, incorporating university scientists into company Advisory Boards)
ii) Bringing in forward cutting-edge research, enabling exploitation of results
iii) Developing innovative concepts at an early stage
iv) Performing work and addressing technical problems difficult to do in-house
v) Exploring new areas of research for exploitation in the future
iv) Access to sophisticated instruments and large scale facilities.

Benefits reported by **doctoral candidates** clearly reflected their main motivations:
i) Gaining insight of the non-academic sector
ii) Working on "real life" research problems
iii) Enhancing their employability opportunities, especially outside academia
iv) Having an opportunity to network in a wider environment, especially outside academia.

Examples from the Case Studies: Benefits

- *UPMC:* "The benefits are numerous: mutual knowledge, trust and respect, sharing of resources and facilities, joint development of new technologies or devices of interest to the companies, access for academic laboratories to specific/confidential data, in most cases sharing of technology transfer and commercialisation of research results."
- *Arcelor Mittal*: "Associated laboratories are full of interesting skills and competences. Their scientific engines are high-performance and allow very innovative research. Collaborating with them makes access to very basic research easier for Arcelor Mittal."
- *Doctorate holder – EURODOC:* "Yes, it has made me more employable in industry. Industry employers appreciate that you have gained experience in working with their particular industry and gained insights into how it functions."

Source: EUA DOC-CAREERS Project

3.3.3. Challenges

A series of challenges in setting up and taking forward collaborative doctoral projects were consistently identified in the DOC-CAREERS case studies. Each organisation operates within a particular culture and each gives a particular perspective to the challenges and risks. The differences can make the unique collaborations beneficial for all partners but in fact, when comparing overall the challenges that business and universities say they face, it is noticeable that they are conceptually the same and they reciprocate each other's interests. Hence, in this section, each challenge will address both points

3 Doctoral Programmes in Cooperation with Industry: Contexts, Trends and Strategies

of views. When it was possible for the doctoral candidate to participate in the setting up of his/her thesis, they reported the same type of general problems identified by universities and businesses.

Challenges in establishing the partnership

• Identifying partners who value university R&D/industry R&D

A challenge reported by **universities** willing to begin or to expand relations with businesses is the identification of partners who value university R&D. Normally, universities rely on relationships built upon previous personal contacts during education, research and consultancy projects. Universities participating in doctoral schemes funded by governments may find companies which are newcomers to university-business cooperation because they feel safer in such frameworks and they may know about the experience of other companies.

> *"We usually partner with reliable universities with which we had links in the past and who have a good background in the research fields that we want to expand. We are attentive to macro-trends in the world, identifying relevant patents and articles and then contacting the authors."*
>
> Janet Blakely, Dow Corning

In governmental schemes, with strict deadlines for submitting applications, the challenge is to find suitable companies and prepare good proposals in a relatively short time. These types of relations need time to develop and in case of brand new collaborations, there is a strong need to demonstrate sound organisation and commitment between the partners.

Some universities, especially in the engineering and technology areas, reported problems in finding suitable **doctoral candidates** when the university and the company seek candidates who can firmly commit 3 to 4 years to the project. The main risk is that the candidate may find a job elsewhere and leave the doctoral research unfinished, thereby leaving both the company and the university "high-and-dry" after having invested in the project and in the education and training of the candidate. This risk is more common in the engineering and technical areas than in social sciences.

On the industry side, interviewed **companies** normally know the university partner well, value its scientific reputation and rely on their capacity to deliver based on previous projects (e.g. IBM, Corus, Arcelor Mittal, Renault, P&G, Synpo). They may take into account other factors such as the size of the research team and their strategy (e.g. Solvay: "*For us, there is a minimum critical mass – about 10 people/team – and we value long-term vision and planning*") or have geographical preferences (e.g. Lafarge: "*We try to identify leading universities in all the fields we are interested in. Currently, about 60% of Lafarge's partner universities are French. Doing research with universities is very important and enables the company to acquire new skills*").

In the case of brand new relations, enterprises primarily select their university partners according to sound scientific records on the research topic and their global accreditation profile (e.g. Schlumberger, Thales, Lafarge). According to Lafarge: "*Research and industrial worlds are moving together and Lafarge cannot do without trying to collaborate with new universities. Lafarge signs contracts both with well-known and unknown universities. In the latter case, it is crucial to agree upon intellectual property issues from the very beginning of the collaboration*". And on a similar point, Thales: "*In general, Thales collaborates with well known universities or schools. However, recruiting a PhD can facilitate setting up a long-term partnership with unknown but interesting universities. But it is not a rule.*"

• Finding research projects which match industry needs and academic standards (in a timeframe of 3 to 4 years) is another of the main challenges pointed out by both universities and their industrial partners. The win-win projects that can combine the more practical needs of industry with the more scientific and theoretical foci of doctoral theses are normally in the domain of basic research and

it is there also where the least problems with IP rights are to be expected.

Universities reported that companies with little tradition of collaborating with universities tend to request solutions to their short-medium term technical challenges, having "wishful" expectations of early returns on their investment. Some universities also reported that the industrial partners are just interested in the research results and that their involvement in the actual education and training of the doctoral candidate is limited. The main complaints from **business** were addressed to the freedom of publication instinct of universities which worked to the detriment of application, desired by them. In fact, the companies interviewed fully recognise the importance of publication. The challenge is to achieve a proper balance between publishing and ensuring that the knowledge can be commercially applied, e.g. by providing sufficient protection to the IPR.

Examples from the Case Studies: Challenges

- *Haldor Topsoe:* "Universities think collaboration with industry will bring them high revenues. Establishing IP rights is certainly an issue."
- *Infineum:* "IPR is the biggest issue: University wants to publish and that conflicts with confidentiality issues and sharing of royalties."
- *Oridis Biomed:* "University has too strict rules about innovation and inventions. IPR issues are very important for us and there is a risk of university publishing the results."
- *Renault:* "Main challenges are IP and Patenting agreements."
- *Arcelor Mittal:* "At Arcelor Mittal, it is very important to have at least six months of international experience. When setting up a doctoral project, we ask the associated laboratories to use their international network to send the candidate abroad. 80% of Arcelor Mittal PhD candidates are based in France."
- *Stora Enso:* "Our goal is to get good doctoral candidates. We try to identify talents beforehand. Our people holding part time professorships have access to new talents."
- *Simula:* "Retention of doctoral candidates is related to availability of funds and working conditions."

Source: EUA DOC-CAREERS Project

• Reaching agreements – Financial, IPR

Universities pointed out that reaching financial agreement is a difficult matter. The cost-benefit ratio is critical for the external partners (especially in the private sector), and the potential benefits from the research performed by a doctoral candidate may not always be apparent. As TU Delft reported: *"It has always proven complicated to convert good intentions into solid agreements with partners."*

Many of the interviewed **companies** said that, in general, there are no more difficulties in establishing contract agreements with universities than with other types of partners. Almost unanimously, they pointed out that reaching agreement on Intellectual Property Rights and publication policy was one of the most challenging issues during the negotiations. Partners may spend several months (some cases they even reported 'years') before reaching an agreement on IP. This difficulty to converge on common objectives can have a negative impact on the doctoral candidate (Section 3.5.). Because of this, some companies prefer to offer only their facilities to **doctoral candidates**. The companies who collaborate either concentrate on areas of basic research where there is little chance of an immediate commercial application or they work with well-known partners with whom they have built a common understanding of the issues (Arcelor Mittal called these universities "relevant universities").

3 Doctoral Programmes in Cooperation with Industry: Contexts, Trends and Strategies

• **Timely decision making processes, internal management and bureaucracy**
Some **companies** consider that there is too much bureaucracy related to collaborative doctoral projects. Some rely on intermediary organisations which deal with all the administrative paperwork (such as ECRIN in France and the Comunidad de Madrid in Spain). Companies interested in background research, such as Arjo Wiggings, may decide to share one doctoral candidate between several companies, including competitors, to share risks and investment (Section 3.5.).

Universities said that when applying for public funds, it is not uncommon that the university assumes most of the administrative tasks. The risks here are basically two-fold: the withdrawal of the company from the application and the risk of the project not being selected, consequently undermining the willingness of the company to invest in these kinds of projects. As Newcastle reported: "*An issue that is worth mentioning is the complexity of setting these things up with partners and how much work can go into them, only for them to collapse at the eleventh hour due to some difficulty in the partner organisation.*"

While there is little room for changing administrative regulations, internal process decision making and management can be adjusted to facilitate the university-business interaction. Practitioners from both sectors clearly indicated this need as mutual. The usual complaint from **companies** to universities is their slow decision-making processes and their lack of flexibility. **Universities** emphasised as a challenge the actual management of the interaction between the many different types of actors (e.g. how to divide common tasks), ensuring commitment and coordination with the industry.

Universities which currently have little cooperation with industry or low-intensive R&D companies willing to invest more in research strategies involving universities face the need to change the culture of their own organisation and re-structure internal decision making processes. Some universities (such as Mykolas Romeris and Hanken) recognise that their university research staff and administrative personnel have limited experience with university-industry relations and that they "learn while doing", leaving them little room and limited capacity to handle the unexpected.

Some **companies** are also aware that dealing with universities would require changes in the culture of the company and also adjustments on the professional profile on the part of the management staff. For example, Eurofins said: *"At present we don't have strong R&D cooperation with universities but we need to think about future links. This takes time and we need the right people and to change the culture of the company. The main difficulty lies in internal organisation issues, managers and knowledge about cooperation".*

Time from first contact to the actual start of the project vary, depending on the partners, the project, the administrative procedures and the experience of the respective management teams in university and industry. In the case of specific projects almost ready to submit to granting schemes, case studies reported time lags of four to six months. Oridis Biomed, Austria: *"The Austrian university system changed in 2002. Nowadays, the role of the rector as CEO of the university has been strengthened. It would be very good for us if they could simplify internal line decision making because setting up projects takes a long time. As an SME, we cannot afford more than two months to reach agreement to carry out a project. Initiatives that require identification of partners and research projects of common interests may take as much as two-three years, especially when IPR is at stake."*

• **Raising awareness of the potential of university R&D to industry:** Motivating a non-academic organisation to recognise "what is in it for them" is a challenge related to identifying win-win situations in research projects. Convincing it of the advantages to be gained from doctoral collaboration can require extensive negotiation. This is easier where the university partner has a clear understanding of the needs and problems of the sector and the environment in which the partner organisation operates. In this regard, it is essential that partners are clear about expected research outputs and timescales and start negotiations as early as possible to take account of possible delays.

Areas in ESS disciplines have more difficulties normally in raising awareness of the value of university research to industry. As Newcastle, Mykolas Romeris and Matej Bel commented, they may not realise the potential benefit or added value of the cooperation, or the shorter time horizon of the non-academic partner can make a three year doctoral project unattractive for fulfilling immediate organisational needs. It is definitely easier to try and build dialogue with businesses that think beyond short-term profit-making and develop a strategic vision for their business and a sense of their corporate social responsibility. This is also true for SET and BML areas but is especially difficult in ESS where, in addition to the limited awareness and practice, there is a general lack of public incentives to attract companies with relevant interests in the sector.

Challenges in Taking Forward the Doctoral Thesis

Some of the challenges mentioned above can remain for the duration of the entire doctoral project, such as the timely decision making processes, management and conflicts related to IPR. Challenges for universities, industries and doctoral candidates in taking forward the project will be extensively dealt with in the next sections of this chapter. They are summarised in Table 3.3-2 and below:

For **universities**: i) Attracting and retaining qualified candidates able to work simultaneously in industry and university environments; ii) Continuously delivering new knowledge perceived as valuable to the corporate world; iii) Facing peer pressure - "selling (cheaply) the university research"; iv) Facing possible threats to university career development; v) Implementing timely decision making processes and management.

For **industries**: i) Attracting and retaining qualified candidates able to work simultaneously in industry and university environments; ii) Balancing targeted industry research and openness to breakthrough knowledge; iii) Implementing timely decision making processes and management.

A major challenge highlighted almost unanimously by all participant universities was to deliver continuously to the corporate world new knowledge perceived as valuable by the businesses. This is a general challenge related to university-industry cooperation and it is not particular to collaborative doctoral education.

Another major challenge indicated by universities and companies was the attraction and retention of well qualified doctoral candidates. The selection process of the doctoral candidate depends very much on the funding scheme and the type of project. Sometimes it is mandatory to have selected a doctoral candidate before the project is set up with the industry (e.g. Athens), but quite often the candidate is proposed either by the university to the company or vice-versa (e.g. P&G, Arcelik, Schlumberger, Athens). Problems in finding suitable candidates may relate to the experience requested by the company, for example, if they want somebody with work experience or international experience.

From the **doctoral candidate's** perspective, the day-to-day challenges that they face during the development of their collaborative doctoral theses are basically related to dealing with the two different, sometimes conflicting, dynamics and pressures of the academic and non-academic worlds. Foci, expectations and timescales can be very different and dealing with these need good management practices. Some candidates found that they held higher expectations of their work with industry than was achieved from the actual experience. Others mentioned conflicts about the division of time spent in university and in industry facilities. A common challenge mentioned by the successful candidates was that they often had to draft two different reports based on the same research outcomes to meet the different needs, expectations and formats of the academic and non-academic environments.

A few doctoral candidates reported disappointment with industrial supervisors who were not sufficiently interested in their academic work. As a Newcastle doctoral candidate said *"My work was very dependent on interpersonal dynamics and subject to different people's agendas in the organisation"*.

Table 3.3-2 Summary of motivations, benefits and challenges identified through DOC-CAREERS cases

Universities	Industries	Doctoral Candidates
Motivations		
• Exposure to wider research environments • Improving the quality of doctoral education and institutional reputation • Enhancing employability perspectives of doctorate holders and their social status • Responding to the growing industrial demand for access to generated new knowledge • Attracting more and more diversified funding from external organisations for research • Better integration in the ERA • Stimulating university-industry dialogue	• Access to cutting-edge research • Recruitment: access to highly qualified working force • Staff career development	• Gaining insight of the non-academic sector • Facing "real life" research problems • Enhancing employability opportunities, especially outside academia • Opportunity to build up a network of contacts outside academia • Ready made ("jump in work") projects
Benefits		
• Promoting innovation, entrepreneurship and social responsibility • Incorporating industry input within university research • Gaining awareness of technical challenges facing companies • Providing highly qualified workers to the labour market • Contributing to sustainable funding for research and research infrastructure • Enhancing quality of research management	• Bringing highly qualified work force and scientific know-how • Bringing cutting-edge research, enabling exploitation of results • Developing innovative concepts at early stages • Performing work and addressing technical problems difficult to do in-house • Exploring new areas of research for exploitation in the future • Access to sophisticated instruments and large scale facilities	• Gaining insight of the non-academic sector • Facing "real life" research problems • Enhancing employability opportunities, especially outside academia • Networking in wider environments
Challenges in establishing the partnership		
• Identifying partners who value university R&D • Finding research projects which match industry needs and academic standards • Reaching agreements (financial, confidentiality, IP Rights) • Timely decision making processes, internal management and bureaucracy • Raising awareness of the potential of university R&D to industry	• Identifying partners who value industry R&D • Finding research projects which match industry needs and academic standards • Reaching agreements (financial, confidentiality, IP Rights) • Timely decision making processes, internal management and bureaucracy	When it is possible to participate in the setting up of their doctoral project, challenges generally include those pointed out by universities and enterprises.
Challenges in taking forward collaborative project/programme		
• Attracting and retaining qualified candidates able to work simultaneously in industry and university environments • Continuously delivering new knowledge perceived as valuable to the corporate world • Facing peer pressure - "selling (cheaply) the university research" • Facing possible threats to university career development • Implementing timely decision making processes and management	• Attracting and retaining qualified candidates able to work simultaneously in industry and university environments • Balancing targeted industry research and openness to breakthrough knowledge • Implementing timely decision making processes and management	• Satisfying simultaneously the needs and expectations of university and industry, as well as the candidate's • Dealing with different, sometimes conflicting dynamics and pressures • Dealing with different levels of interest of partners • Having to "duplicate" research outcomes reports

Source: EUA DOC-CAREERS Project

3.4. Characteristics of Collaborative Doctoral Programmes

3.4.1. Main Components of Collaborative Doctoral Programmes

As reported in the previous sections, the DOC-CAREERS university and industry case studies reflect a variety of approaches to collaborative doctoral education. Every case illustrated a quite unique formula, depending on the individual situation, field of knowledge, objectives and culture of the stakeholders. Nevertheless, there is a common pattern which can be characterised by a set of the seven main components: a) strategic level of engagement in the organisations – university and industry; b) role/s of industry; c) selection of the doctoral research topic; d) doctoral candidate additional admission requirements; e) formal agreement; f) legal status of the doctoral candidate; g) supervisory scheme. These components, in their turn, can be expressed in different elements and ways. Following a description of their concepts below, there is a comprehensive summary and a synopsis in Table 3.4.1-1 highlighting the essential components and framework possibilities when setting up collaborative doctoral schemes.

Component Concepts

a) Strategic level of engagement in the organisation – university and industry

This component refers to the organisational level that is engaged in the collaborative doctoral collaboration and reflects the degree of organisational commitment in the specific programme. In a **university**, the engagement beyond the formal signature of the institution authorising a collaborative project could lie either at the level of a professor/staff researcher, as is the case of individually-driven type of initiatives, or in formal units such as an official research group or laboratory, department, graduate school or the whole institution, in the case of university-driven types of initiatives. In the latter case, the university as a whole would have established a strategic plan and taken actions to motivate researchers to develop more contacts with industry. In a **company**, the level responsible for the doctoral collaboration is directly related to the company strategy and the role they decide to play in the programme. Industry-driven doctoral programmes are normally seen as part of the implementation of a clear long-term research strategy adopted by the top management of the company.

b) Role/s of industrial partners

The DOC-CAREERS cases demonstrated that industry contributed to collaborative doctoral projects/programmes with five main types of activities: supervision, funding, placements, data provider and network facilitator.

- Supervision: this role is key in defining a doctoral programme as collaborative because it demonstrates involvement of industry in the training of the doctoral candidate.
- Funding: in the form of part or full payroll of doctoral candidate, provision of infrastructure, research material, access to industry facilities, industry seminars, etc., industry commits their resources and expects something valuable for them in return. Funding and legal status of the doctoral candidate are intimately related and this point is specifically addressed in point 'f' below).
- Placements: as indicated in Section 3.2., traineeships in industry premises are one of the most valuable experiences for doctoral candidates to embed industry culture and values in their mindsets through research activity. This exposure is a clear added value to fostering knowledge transfer and mutual understanding between the university and industrial worlds. It is often the case that

SET and BML programmes offer more structured placements in industry, shorter or longer, depending on the project. In the context of a collaborative doctoral thesis, we understand a "structured placement" as a period of time spent in industry premises and an integral part of the education of the candidate, no matter if it is mandatory, as it may be the case of government-driven initiatives, or agreed individually between the university and industry. Placements in industry can be spent in one single period or distributed in multiple periods throughout the project or be daily, part-time, etc., depending on the nature and needs of the project and/or the policies of the parent organisations. Also, depending on the company policy and the nature of the project the candidate may be placed either in a company research group or work mainly individually using laboratory and equipment facilities for his/her own research.

- Data provider: many companies participating in collaborative doctoral programmes allowed the candidate to use their empirical data to work with, of course within due disclosure policy. This is also another very important contribution highlighted by practitioners in all SET, BML, and ESS areas because it contributes to the sense of "reality" pointed out as a main motivation for working with industry environments. This role is particularly important in the case of ESS areas.
- Network facilitator: the opportunity for the doctoral candidate to start building a network of contacts outside the academic environment is a "soft" direct benefit which comes naturally when working closely with industry. In that sense, placements in industry facilities and participation in company meetings and seminar enhances the value of the collaborative experience.

Out of the 31 companies interviewed, 27% contributed with funding, 22% hosted doctoral candidates, 50% participated in supervisory committees and 23% allowed their data to be used by the candidates in their research.

c) Selection of the doctoral research topic

A doctoral research topic that meets both academic standards and relevant industry needs may be decided by any of the parties involved, whether individually or jointly. Basically, all combinations were found in the DOC-CAREERS cases:

- by the candidate (e.g. Aarhus, ESADE)
- by the candidate in cooperation with the supervisor (e.g. Hanken, Simula)
- by negotiation taking account of the needs of the candidate, the university and the business (e.g. Athens, Cagliari, Bangor)
- by negotiation between the HEI and the industry (e.g. Newcastle, Paderborn, TU Delft)
- by a research programme: the company and the university jointly set up a project in the framework of a pre-established research programme or strategy with defined research priorities (e.g. Mykolas Romeris, UPMC, Matej Bel).

Approximately, in 60% of the DOC-CAREERS cases, the research topic was selected by negotiation between the university and the enterprise and in 35% the companies decided exclusively and the candidate could only suggest minor changes. In only 5% of the cases was the doctoral candidate able to bring in his/her ideas and develop them. This practice was found basically in large companies, which welcome spontaneous applications from universities and doctoral candidates.

Examples from the Case Studies: Selection of the doctoral research topic

- *Arcelor Mittal:* "Arcelor Mittal decides the doctoral subject based on its specific needs. We need candidates with skills which we don't have in the company."
- *Renault:* "Business needs are the first priority, university's views second and candidate's views third."
- *Doctoral candidate, Newcastle:* "I felt my suggestions were taking second place to the original research design, which I understood, but I felt 'Whose PhD is this going to be, anyway?!'"

Source: EUA DOC-CAREERS Project

d) Doctoral candidate additional admission requirements

Doctoral candidates willing to pursue a collaborative doctoral education may have to fulfil additional requirements on top of the university's policy admission to doctoral education. The most common academic degree required to enter collaborative doctoral programmes is the Master, with or without professional experience, depending on the programme. Bachelors are also admitted depending on the university policy, doctoral programme and on the personal skills of the candidate (see more details in Section 3.5.).

For admission to industry-driven doctoral programmes or to those in which the industry hosts the candidate as if he/she were an employee, candidates may have to go through additional company interviews and/or follow company standard human resources procedures for recruitment. If the candidate is to spend a large amount of time in the company and is going to be seen as a potential employee, interpersonal skills and his/her potential fitness in the company culture are very important (e.g. Philips, Renault, Arcelor Mittal).

Examples from the Case Studies: Special practices on admission requirements

- *IBM:* "Yes, there is a selection procedure: 1) assessment of CV, 2) consultation with referees, 3) one-day interviews/assessment in the lab. Usually we select 1 out of every 4 candidates (candidates who were already very good). Usually, in one year, from 40 applicants selected for assessment, we hire 8-10."
- *SIMULA:* "Unlike the ordinary doctoral training programmes at Norwegian universities, PhD at Simula School has a duration of four years. During the first year students are trainees who are introduced to research methodology, normally working with other researchers. Placements in companies also take place, in order to select problems suitable for developing a research project for the PhD dissertation. This first year is also a mechanism of pre-selection of students considered most capable and motivated to follow-up and complete PhD studies."

Source: EUA DOC-CAREERS Project

3 Doctoral Programmes in Cooperation with Industry: Contexts, Trends and Strategies

e) Formal agreement, general conditions

The signature of a contract or formal agreement at the beginning of the collaborative doctoral thesis is a sign of trust and commitment between the parties and establishes boundaries, resources and type of support that both parent organisations can commit to the project. This is especially relevant in case of problematic situations. The signature of a fair agreement is a clear indication of good practice. Contracts or formal agreements between the three parties, university, industry and doctorate holder, normally include, in broad terms:

- description of the research project
- duration of the research, committed resources and financial provisions
- rights and duties of each party: supervision of the doctoral candidate, monitoring of the progress of research, reporting periods and deliverables, placement conditions, dedication, meeting arrangements, health insurance, compliance with standard procedures of university and industry if they exist, etc.
- confidentiality issues, IP ownership and rights over research outcomes with potential commercial use
- contingency plans
- other specific items: liability clauses, general conduct of the research, etc.

A contract at the beginning of the collaboration is mandatory in government-driven initiatives. Industry-driven or university-driven initiatives may require the signature of a contract but not necessarily between the three parties. Some industries prefer to sign a collaborative research contract with universities and leave up to them the tasks of recruiting and handling legal aspects with the doctoral candidate. Contracts are more common in SET and BML areas of knowledge than in ESS. In ESS fields, the role of industry is frequently that of a funder/data provider to conduct the research, and a confidential agreement specifying the terms of use of data and name of the participant company may be enough (e.g. the case of a doctoral candidate developing a doctoral thesis in economics using data from a company). Companies are normally the first interested in signing an agreement. The main concern they all pointed out was to provide a sound basis for settling IP Rights (e.g. Corus, Haldor Topsoe, IBM, Philips, Renault, Solvay, Arcelor Mittal, Synpo, Thales, P&G, Schlumberger).

Newcastle Case Study: "Lack of any formal agreement between the academic and collaborating organisation is sometimes the result of a long-term pre-existing relationship between the partners, based on trust. However, rapid change of personnel and ownership in non-academic organisations can present problems, and this was evident in several of the Newcastle collaborative studentships. Often the research studentship is the passion of an individual in an organisation, rather than the whole organisation. The Research Councils try to ensure that there is a deep commitment to the project by the organisation, but this is not always the case. Formal agreements about the arrangements for the studentship can minimise problems when a project is transferred to a new supervisor in the non-academic organisation, or help to resolve any misunderstandings arising between partners in a non-contentious way."

Contingency plans to ensure the completion of the doctoral thesis can also be part of these contracts in case of an eventual business withdrawal from the project (due to change of research priorities, business strategy, crisis, etc.). Although many companies try to fulfil the contract conditions to the end, a company in difficult times may try to reorient the project to new priorities and/or find ways to secure the necessary funding for the completion of

> ***"Research priorities may change. In this case we meet with the professor/s to re-negotiate and try to keep the research topic as close as possible to the original to not cause harm to the doctoral progress."***
>
> Hans Hofmann, IBM

the thesis. In case of unavoidable industry withdrawal, some programmes replace a company by another one or find a way to host the doctoral candidate until completion of the thesis (e.g. SIMULA).

Formal agreement: Confidentiality and Intellectual Property Rights

As in any other type of university-industry collaboration, many industries and universities reported that they encountered problems in settling timescales and clearance procedures for publication, the ownership of IP and the rights to exploit this IP. Table 3.4-1 summarises the main issues in this section. Industries generally fear that universities, driven by their needs and culture to publicising research results, will prematurely disclose outcomes with potential commercial use, risking their possible future exploitation under due protection rights. For this reason, in the specific case of collaborative doctoral education some universities and companies tend to work in fundamental research areas, avoiding any IP matter (e.g. Arcelor Mittal, OCE). This is a good solution for companies with a long-term R&D strategy. Other industry-driven initiatives created their own programmes to specify their conditions or worked with very well known selected university partners with whom IPR issues had already been settled (e.g. Philips-Van der Pol, Thales).

Resolving such issues may take less or more time depending on what is at stake and the attitudes and approaches adopted by the partner organisations. Universities and enterprises interviewed reported time spans ranging from 3 months to 2-3 years. However, the case studies indicated the partners did eventually come to a common understanding. Despite the challenges and difficulties associated with (for example) IP, it should not be in itself the reason to avoid commitment to collaborative doctoral education. It is indeed very important to differentiate between the doctoral process and its research outcomes of academic value leading to publication and the commercial exploitation of research results. For many university-driven initiatives, the chosen formula reflected a joint recognition that *"It is possible to retain ownership and control of IPR and to license the rights to exploit it.'"*.

A good practice in collaborative doctoral programmes is to include in the initial agreement establishing the IPR regime, a clause that allows publication of results of academic relevance while setting up mechanisms to prevent early disclosure of research results with potential commercial value. Universities aware of IPR issues involved their legal services when necessary (e.g. Hanken, ESADE). Many universities and industries used internal IPR policy open to negotiation or not (e.g. Masaryk, IBM, Microsoft, Renault). Other universities used their national policy frameworks (e.g. Mykolas Romeris, UPMC). In cases where industry provided data, an agreement ensuring the anonymity of firm or, just the opposite, obligation to mention it, was required (e.g. ESADE).

Table 3.4-1 Confidentiality/disclosure agreements and IP rights

Ensuring right to publication of results with non-commercial application: • Preserving anonymity of the name of the non-academic partner • Requiring disclosure of the name of the non-academic partner	Protecting rights over results with commercial application IP Ownership: • Retained by the participant firm • Retained by the participant universtity • Shared ownership IP Rights to exploitation: • Exclusive to the participant firm • Non-exclusive	Dealing with IP Rights: • Internal standard agreement – non-negotiable • Internal standard agreement – negotiable • National policies • Only well known partners with whom IPR has already been settled

Source: EUA DOC-CAREERS Project

Traditionally, universities have been very flexible, even disinterested, in terms of IPR, frequently granting them to the firms, receiving no or little part of the royalties, and avoiding involvment in IPR management. This trend is nevertheless evolving as universities are becoming more aware of the potential value to themselves, and the need to secure a fair return for public investments in education and research. This has given rise to growing complaints regarding universities' expectations of higher returns from their collaborations with industry. Everything is indeed costly: it takes years to build a research infrastructure and educate a good researcher and it also may take years to develop a new commercial product or service after a breakthrough idea has been generated. It remains an open question how to address these problems.

Examples from the Case Studies

University-driven initiatives

- *TU Delft:* "In general the research and education rights are held by TRAIL and the exploitation and development rights by the partners. Financial returns are distributed accordingly to the respective partners' contribution."
- *Paderborn: "*Our PhD-candidates are students of the university. Therefore they have complete rights on their results. The property rights on the results, inventions made by university members (e.g. the supervisors) in the projects are fixed in a contract between the university and the industrial partner. In principle these are instances of the general regulations by law."
- *Bangor (using Structural Funds):* "State Aid is an issue if we grant IP Rights to the company. University has kept IP rights, (to grant in exclusivity or non-exclusivity). Usually that is not a problem because we do only long-term research, with no immediate commercial benefits. SME concerns on IP vary very much. Agreements are set up with lawyers of company and university."

Industry driven-initiatives:

- *Solvay:* "We have two formulas: exclusive IP rights and non-exclusive IP rights plus royalties. When negotiating IPR, four people sit around a table: the Solvay R&D Director, a Solvay lawyer expert on IPR, the university research leader and a university lawyer expert on IPR."
- *Microsoft* has a standard contract usually accepted by the university: "Trust among partners is essential: we hold non-exclusive rights and we let the results be publicised. Our main return is building strong relations with university which provide students who are potential employees."
- *Stora Enso:* "Legislation in IPR is old fashioned and in universities there is a complete lack of understanding of IPR management issues. We need a change in legislation, in university mindset and university experience."
- *Lafarge:* "Generally speaking, intellectual property issue is not too difficult. But it is very important to consider it when establishing a new partnership. Shared IPR can be an issue. Sometimes, the partner may want too many things."

Source: EUA DOC-CAREERS Project

f) Legal status of the doctoral candidate

Funding and legal status of the doctoral candidate are intimately related. In government-driven collaborative doctoral programmes, a status of employee or research fellow is granted according to the policy in place. In industry-driven programmes in SET and BML areas the industry normally pays a high proportion of the salary of the doctoral candidate. In ESS fields is not uncommon that the candidate is self-employed or employed by a company or academic institution and that he/she does not have a status as a doctoral candidate (by undertaking a doctoral project their aims may be to enhance their employability prospects and/or satisfy their intellectual interests).

A doctoral candidate should always seek to have a legal cover that would establish a set of rights and duties, cover health issues arising from working in the doctoral project and protect the authorship of his/her research outcomes. Legal status can be grouped in five general types:

- fellowship/student of the university
- fellowship from a public research funding body
- employed by the university (teaching or professor assistantships, researcher)
- employed by the industry or industry employee seconded in university
- self-employed

3 Doctoral Programmes in Cooperation with Industry: Contexts, Trends and Strategies

Doctoral candidates should be aware that a collaborative research contract between a company and a university does not necessarily give them a legal status. In individually-driven programmes this depends on the agreement between the parties. Normally, structured collaborative doctoral programmes, either university, industry or government-driven, do allot a legal status to the doctoral candidate.

g) Supervisory scheme

A key component of collaborative doctoral programmes is that an industry expert is made part of the supervisory committee in addition to any other contribution such as funding, placements, data provider, etc. Industry can play all these other roles in contract research, but without direct involvement in the supervision of doctoral candidates this would not constitute a collaborative doctoral project. The supervisory committee is where the specific purpose of the project is monitored and ensured. In SET and BML areas, a joint approach is very common and supervisory committees normally include 1 or 2 university professors, 1 or 2 industry experts and sometimes a career development expert (e.g. ESADE, UPMC, TU Delft, Simula, Bangor). Some companies have employees who hold part-time professorships (e.g. Hanken, Athens, Newcastle, Paderborn, Simula) and these are ideal profiles for supervisory committees in collaborative doctoral theses. Some institutions, such as UPMC and Newcastle, have their own "good practice" guidelines for supervision.

The frequency of meetings of the joint supervisory team was found to be extremely diversified, from daily exchanges to every 6 months or once per year. The reasons that determine the frequency depend on many variables such as the nature of the research, the level of trust, the physical distance to meet and the agreed level of commitment. Reporting periods also varied very much, from 6 month to 1 or 2 years, 1-2 years being the most common reporting period for assessment and follow-up of the doctoral thesis.

Data Collection and Tracking of doctoral graduates' careers

Institutional tracking of first degree graduates is becoming normal practice in many universities but institutional tracking at doctoral level is still the exception rather than the rule. Based on the findings of the DOC-CAREERS, it is proposed that data collection and tracking of doctorate career holders should be an integral part of the institutional framework for doctoral programmes in general and of collaborative programmes in particular. This practice is already mandatory in government-driven initiatives, such as CIFRE and Marie Curie Actions where the institution commits by contract to inform the granting body the professional destination of their doctoral graduates. Issues related to tracking methodologies, challenges and benefits are addressed in detail in Chapter 5 and a sample of employment outcomes of doctoral graduates supplied by several of the university case studies is found in Annex 7.4.

Given that it is estimated that in Europe 50% approximately of the doctoral holders work outside academic environments and that this percentage could increase in the coming years, the tracking of data on doctorate holders from collaborative programmes would produce valuable information on career destinations and could inform curricula.

Examples from the Case Studies
Joint Supervisory Schemes in Collaborative Doctoral Programmes

- *P&G:* "The supervisory scheme depends on each case. In general, PhD students like having two supervisors: one from university and the other one from business. In general, there is no problem of disagreement between both supervisors."
- *Schlumberger:* "The doctoral candidate is supervised by both the academic laboratory and corporate laboratory. Supervision of the university is independent from the supervision in company. Olivier Peyret considers that this independency is a ground for new out-of-the-box ideas. Schlumberger has a monitoring system in place to receive regular feedbacks (for candidates who are not linked to CIFRE contracts, the academic supervisor is responsible for the monitoring)."
- *IBM:* "From the university side, reporting frequency depends on the supervisors, ranging from day-to-day basis to 4-6 times per year. From IBM side we ask for a progress report at the 1st or 2nd year."
- *Lafarge:* "If the objective of PhD project is to provide more applied research the doctoral candidate will be located at Lafarge in order to have access to Lafarge's scientific equipment. The candidate then meets his/her PhD director at university once a month. If the objective of the PhD is to find new techniques to develop prototypes, the candidate will be located in university's laboratory. In this case, the candidate goes to Lafarge once a month."
- *Hanken:* "Supervisors are experts in the topic area of the thesis and responsible for supporting the thesis work. Members can be from Hanken, other universities in Finland or abroad or be employees with doctoral degrees in business or the public sector. The doctoral studies are to a great extent tailored and the study plan is revised once a year. Many candidates develop theses which are part of the senior researchers' projects (e.g. the TEKES projects and Collert Foundation project), consequently, the students are in daily contact with senior faculty. A characteristic of Hanken is an open-door-policy. Students and faculty interact without always making formal appointments. It is therefore impossible to give an exact estimate of the average frequency of meetings."
- *TU Delft:* "Ways and frequency of supervision meetings vary widely from project to project, but specific agreements are always set in advance. There is a minimum requirement that the candidate shall meet the supervisors at least twice a year."
- *UPMC:* "Both an academic researcher responsible for the doctoral project and a scientific manager in the company are supervisors. The specific modality of this joint supervision is defined in the collaborative contract between academia and company. Frequency of meetings depends on the policy and practice of each laboratory, public and private. Within the public, it could also vary enormously among disciplines (social and human sciences vs. hard sciences for example) and on the supervisor's workload. On UPMC's side, to implement the doctoral education policy, the Institute of Doctoral Training recommends several follow-up procedures in doctoral schools. As the guarantor of the quality CIFRE scheme, ANRT requires at the least an annual activity report of 5 pages maximum, which must be presented by the three partners. To ease their work, ANRT has elaborated a guideline available on the web site."
- *Newcastle:* "There are two academic supervisors for each doctoral student, in line with the University's Code of Practice for Research Degree Programmes, and at least one supervisor from the non-academic partner. Supervisory arrangements vary from studentship to studentship, but the Faculty advises applicants to adapt the generic text to the conditions of their particular circumstances."
- *SIMULA:* "Most of the senior research staff in Simula have a part-time position at the University of Oslo. Supervisors come from companies, Simula and the university. Sometimes one supervisor represents two or three organisations at the same time."

Source: EUA DOC-CAREERS Project

3 Doctoral Programmes in Cooperation with Industry: Contexts, Trends and Strategies

Summary of components and elements

The case studies submitted to DOC-CAREERS have led to the above backbone of seven components and their elements. While we believe this is quite a comprehensive list, there could be additional elements in other collaborative doctoral programmes that have not been identified in this project. Provided that a set of elements ensure a proper framework for the development of a doctoral thesis, it cannot be said that there is a better or worse approach. **Government-driven** programmes usually determine elements and procedures with the aim to ensure good use of public funds and that the quality of research meets both academic standards and industry needs, no matter the field of knowledge. These programmes also require quality assurance in the management of the doctoral process and may give little leverage for decision-making. In **non-government-driven** programmes where there is more flexibility, partners should find the most convenient set of elements and conditions balancing degree of structure and flexibility.

Table 3.4.1-1 shows the components of collaborative doctoral programmes and their elements and indicates two generic models of industry involvement. In **Model A**, the university and the industry are engaged at the top level of management, industry's roles are multiple, the selection of the research topic is open to all possibilities, the admission of the candidate includes industry procedures, there is a formal contract in place establishing the essentials, the candidate has a legal status and, of course, the supervisory committee includes industry experts. This is the case in programmes such as CIFRE, Van der Pol in Philips, CASE and Danish Industrial PhD Programmes. **Model B** represents a softer structure, where the actual levels of engagement are in middle management (with approval by top levels), industry is involved in supervision and provides one or more of the other elements (funding, placements, data provider, network facilitator), the selection of the doctoral research topic remains open to all possibilities, admission requirements are those set by university policy with no further input from industry, and there is –or not– a contract in place and a legal status for the candidate. This could be the case, for example, of a self-funded doctoral candidate working individually on a doctoral thesis using data supplied by a company under agreement.

Practitioners in all sectors and fields agreed that, independently of how well-organised the formal aspects of a collaborative programme may be, it is the personal components, such as the excellence in performing and mutual trust between the stakeholders (doctoral candidate, industry and university researchers and managers), that make the collaboration successful. Cooperation processes are holistic, that is, the soft part of the relationship is very important and regular face-to-face experience is mandatory to build trust and durable partnerships. By allowing an appropriate combination of the above elements and the flexibility to modify them, the institution enables solutions to be tailored to meet the specific challenges of a collaborative doctoral project. What is most important in collaborative doctoral programmes is to have a supervisory committee which includes an industrial member and which is fully committed to all aspects of the doctoral candidate's development and studies.

Table 3.4.1-1 Main components of collaborative doctoral programmes and their different elements.
The last two columns are two generic models, always involving industry in the supervisory committee. **Model A** reflects closer university-industry interaction than **model B**.

Collaborative Doctoral Programmes			
Component	**Elements**	**Generic Models**	
		A	**B**
Engagement Level - industry	Institutional (Official Research Group, Department/Graduate School/University)	✓	
	Professor/Researcher	✓	✓
Engagement Level - industry	Top management	✓	
	Middle management/Research team	✓	✓
Role/s of industry	Supervision	✓	✓
	Placements	✓	
	Funding	✓	
	Data Provider	✓	✓
	Network Facilitator	✓	
Selection of the doctoral research topic	Individual idea: university researcher, industry researcher, candidate	✓	✓
	Team: university-industry, university-doctoral candidate, industry-doctoral candidate or university-Industry-doctoral candidate	✓	✓
	Organisation: university or company either individually or jointly	✓	✓
Doctoral Candidate Additional Admission Requirements	Bachelor/Master degree	✓	✓
	Company interviews and/or HR selection process	✓	
Formal Agreement	One contract, three parties: university, industry and doctoral candidate	✓	
	Two contracts, two parties each: university-industry and university-doctoral candidate	✓	✓
	No contract		✓
Formal status of the doctoral candidate	Student/Fellow of the university	✓	✓
	Employed by the university (teaching or professor assistantships, researcher)	✓	✓
	Employed (or seconded) by industry	✓	
	Fellow of funding agency in host university	✓	✓
	Self-employed		✓
Supervisory committee	University researcher/s	✓	✓
	Industry researcher/s	✓	✓
	Career development expert/s**	✓	✓

* A mark (✓) indicates 'Likely'; an Empty cell indicates 'Less likely'.
** This is more or less likely depending mainly on the university policy. Some universities include career development experts in supervisory teams, regardless of the involvement of industry; others do not have this practice at all.

Source: EUA DOC-CAREERS Project

3.4.2. DOC-CAREERS Collaborative Doctoral Programmes – Commonalities and Particularities

This report has defined seven components characterising collaborative doctoral programmes: engagement level in university and industry, role/s of industry, selection of the doctoral research topic, doctoral candidate additional admission requirements, legal status of the doctoral candidate, supervisory committee including at least one expert from the industry. How were these components and their corresponding elements reflected in DOC-CAREERS case studies? The involvement of industry in the supervisory scheme has been pointed out as the distinctive element from other types of university-industry collaboration. From the 48 university and industry case studies, a total of 26 reported clear involvement of the company in the supervisory committee, hence they are the truly collaborative doctoral programmes/projects in the terms defined in this report. All facts and figures reported in this section refer exclusively to these 26 cases.

All the DOC-CAREERS collaborative doctoral programmes indicated that the candidate went through additional admission requirements such as interviews or company HR recruitment procedures. Also in all cases there was a formal agreement signed between the industry, the university and the doctoral candidate at the beginning of the collaboration, set as appropriate within the legal frameworks in place (even if it was just to ensure the confidentiality of the name of a company granting the use of their data in a research project). The engagement level in university and industry varied depending on each case. The selection of the topic in **industry-driven** initiatives corresponded to the industry exclusively in 33% of the cases, negotiated between the industry and the university in 65% of the cases and only in 2% the topic was suggested by the candidate. In **university-driven** initiatives the selection of the topic corresponded to the industry exclusively in 24% of the cases, universities and industry negotiated the topic in 41% of the cases and 35% reported the idea was suggested by the candidate him/herself.

These characteristics were common to all areas addressed in DOC-CAREERS, SET, BML and ESS. There are, of course, technical and cultural peculiarities related to the field of knowledge but, within each field, in its turn, every project has its own characteristics and the eventual success seems to depend in the end on the capacity of stakeholders to work together, face the challenges and sit around a table as necessary to solve conflicts in a fair way, focussing on the progress of the doctoral candidate.

The three components which frame the actual interaction between the doctoral candidate and the company during the project development are his/her formal status (company employee, university employee -such as teaching or professor assistantship, fellowship), the role/s of the company (funding, placements, data provider) and the supervisory scheme. The particular elements of these components in the 26 collaborative DOC-CAREERS case studies have been summarised in 17 formulae (Table 3.4.2-1). The role of industry as network facilitator has been omitted because it is a "soft" benefit which comes along naturally in the contact with industry. The list may seem extensive with sometimes little differences between the formulae, but the fact is that small differences may mean a lot to the candidate, industry and university partnership.

Each formula in Table 3.4.2-1 was reported by one to three DOC-CAREERS cases and some used several of them at the same time, depending on their internal policy or available funds. The Table is organised by areas of knowledge (SET, SET/BML and SET/BML/ESS) and contributions from industry. More than one area of knowledge is indicated for those universities and companies working with doctoral candidates in all these fields (e.g. some large companies with strong SET or BML R&D also work in ESS R&D to study the social impact of new technologies and products).

In the Collaborative Doctoral Programmes part, the first group of thirteen formulae include placements in industry and correspond to programmes usually in SET and BML areas.

The last four formulae do not but involve partial funding and/or data providing by the company. The three Non-Collaborative Doctoral Programmes are DOC-CAREERS case studies with industry interaction but no involvement on their part in the supervisory scheme. These were reported as well by one to three universities and companies and are examples of doctoral programmes described as "with limited involvement of industry" in Section 3.2.

Table 3.4.2-1 Collaborative Doctoral Project Schemes

Field	Doctoral Candidate Formal Status	Industry Funding - Salary	Placements in Industry[1]		Data from company	Supervision by
SET	Company employee	Up to 100%	15%	Individual/Group	Yes	Univ & Ind
	Company employee	60%	60%	Group	D/P	Univ & Ind & Career Counsellor
	Company employee	100%	70%	Individual/Group	Yes	Univ & Ind
	Company employee	100%	D/P	Individual/Group	Yes	Univ & Ind
	Company employee; Fellowship	40%-60%	D/P	Individual/Group	Yes	Univ & Ind
	Company employee	80-100%	D/P	Group	Yes	Univ & Ind
	Company employee	D/P	D/P	Group	Yes	Univ & Ind; Univ
SET, BML	Company employee; University employee; Fellowship	Up to 100%	D/P	Group	Yes	Univ & Ind
	University employee; Fellowship	D/P	D/P	Individual/Group	Yes	Univ & Ind
	University employee; Fellowship	65%	D/P	Individual/ Group	D/P	Univ & Ind
SET, BML, ESS	Company employee	40-60%	D/P	Group	Yes	Univ & Ind & sometimes Career Counsellor
	Fellowship	40%-60%	25%	Individual/Group	D/P	Uni & Ind
ESS	Fellowship	Up to 20%	D/P	D/P	Yes	Univ & Ind
SET	Fellowship	20%-40%	NO	-	Yes	Univ & Ind
	University employee; Fellowship	D/P	NO	-	NO	Univ & Ind
ESS	Company employee; Fellowship	Up to 20%	NO	-	Yes	Univ & Ind; Univ
	Company employee; Fellowship	Up to 20%	NO	-	Yes	Univ & Ind
Non-Collaborative Doctoral Programmes						
ESS	Employed elsewhere	Up to 20%	D/P	D/P	Yes	Univ
SET, BML	University employee; Fellowship	D/P	D/P	Individual	D/P	Univ
SET, BML, ESS	University employee; Fellowship	D/P	NO	-	D/P	Univ

[1] Indicative percentages in relation to the total duration of the doctoral thesis; D/P means: Depends on the Project

Source: EUA DOC-CAREERS Project

3 Doctoral Programmes in Cooperation with Industry: Contexts, Trends and Strategies

An interesting remark from the large R&D companies which welcome proposals from university researchers was that they benefit from competition amongst universities, because the best researchers want to work with well known companies and present excellent proposals.

Examples from the Case Studies
Funding doctoral candidates' salary and placements in the industry

- *Corus:* "Our company pays the full salary of the researcher. The basic condition is that his/her thesis should benefit the company. Internships are very appreciated and we consider they are essential. Duration ranges from 2 weeks to 2 months. Internships are available for Master, Doctorate holders or Post-docs."
- *Haldor Topsoe:* "The industry hires the person. 35% of the salary comes from the government."
- *IBM:* "60% IBM & Facilities. Salary 40% university."
- *Microsoft:* "In France we make use of the CIFRE programme. In Ireland we have contacts with the Irish Research Council."
- *Philips:* "50% funded by Philips and 50% funded by EU Programmes."
- *Renault:* "40-60%, as established in CIFRE."
- *Arcelor Mittal:* "According to available funding Arcelor uses several formulas: 1) In general, Arcelor funds the student's wages as well as the associated research laboratory expenses. It receives a grant from ANRT. 2) If the associated research laboratory already has a grant dedicated to a specific project which has some interest for Arcelor, Arcelor funds laboratory expenses and the laboratory will fund the doctoral candidate's wages. In this case, the laboratory is responsible for the student. 3) If the doctoral candidate is not European but his/her skills are really very interesting for Arcelor, Arcelor pays the wages as if he/ she were a researcher and also pays associated laboratory expenses. Indeed, in general, when the student is not European, bureaucracy is too long (between 8 and 10 months) and too difficult."
- *Lafarge* "pays the student's wages and partially refunds the research expenses of the partner university."
- *Synpo:* "When the doctoral candidate is employed by Synpo, Synpo funds 100% of the PhD. But on average, Synpo funds between 40% and 60% of PhD costs. Candidates who are paid by Synpo work in the company on a full-time basis. Candidates can also be regular students if they are paid by the university (under Synpo leadership). Then, they spend little time at Synpo."
- *Thales:* "The real issue is to define clearly what the deal is: what can Thales expect from the partnership and in return, how can we contribute? CIFRE candidates are considered from the beginning as engineers, not as trainees."
- *Arcelik:* "If the candidate is officially employed by Arcelik, the company will totally fund his/ her PhD (100%). If this is not the case, Arcelik can fund up to 80-90% of the PhD."
- *Schlumberger:* "Placements are very interesting and essential for all but it should all fit naturally into the general purpose."

Source: EUA DOC-CAREERS Project

3.4.3. Structural Conditions in Relation to Disciplinary Areas

So far we have been analysing the collaborative doctoral programmes without examining the discipline particularities more closely. It is not easy from the limited size of the case studies to extract sound conclusions related to the broad areas of fields of knowledge addressed in DOC-CAREERS. However, together with the output of the dialogue workshops and the contributions from all the other stakeholders, some trends concerning structural conditions in two main areas SET/BML and ESS are noticeable:

Science/Technology/Engineering (SET) and Biotechnology/Medical/Life Sciences (BML)

These fields have a tradition of cooperation with industry, in varied and different forms

throughout Europe. However, the scientific-technical mindset in scientists often overshadows informal contact and promotion. Behind the formal procedures such as joint supervision or temporary placements in industry, successful long-term university/industry cooperation processes are holistic. The soft part of the relationship is very important and continuous face-to-face experience is required to build trust and durable partnerships. Interchanging lectures between business and university can be a very powerful and motivating means to establishing collaboration in education. As an example, one innovative practice from Ruhr University Bochum (Germany) to foster university/industry cooperation includes the organisation of lectures from industry professionals by the doctoral candidates themselves. These contribute to raise awareness of wider and interesting professional development outside academia. These sorts of initiatives could also serve to attract and retain candidates who might be turned away as a result of negative signals given at an early stage.

In this context, several structural conditions were identified as good grounds for successful industry-university cooperation in doctoral programmes:

- Partnerships should be established whenever possible with a long-term view, since it is in the long-term that university and industry can better find opportunities for collaboration. University research is a long-term business and so is doctoral education.
- The overall industrial community including large and medium-sized companies and small enterprises establishes generally collaboration with those university researchers whom they consider reliable and with whom have developed trust in previous projects.
- Focus on building partnership: universities and industries should focus on building the partnership itself rather than just on individual, short-term projects, because opportunities can arise as a natural consequence of sharing a long-term view on the research topic.
- Another factor considered as structurally important to encourage university/industry cooperation was the support from governments as facilitators of the interaction and their assistance to enhance awareness of Intellectual Property Rights (IPR) issues.

Employability: Intersectoral mobility and interaction during the doctoral education period is, in general, highly valued by employers outside academia because it complements the education received. The value of mobility lies in providing exposure to different environments and in the benefit that the individual gains from learning and playing different roles, interacting with different people and building up his/her own network of contacts. Although mobility - within academia or between academia and industry - during the doctoral period is not, and should not be seen, as mandatory, it can help to improve the chances for employability, especially outside academia (Chapter 4). Good employability prospects enhanced by mobility experiences could also help to mitigate the well known European "brain drain" phenomenon.

There is a common view in academic circles that moving from academia to industry is a second class choice, a sort of failure in earning a place in academia. This mindset is easily transmitted to new generations of doctorate holders, hence hindering their opportunity to develop careers outside academia that can be equally fulfilling and beneficial for the society as those in academia (Chapter 4).

Economics and Social Sciences

Collaboration between university and business/industry in economics, social sciences and the humanities is more limited than in other sciences. It seems that it works better in fields such as law and business/economic studies (especially in the form of traineeships and internships of doctoral candidates in banks or companies, e.g. in the areas of patenting and IPR). For instance, the European University Institute in Florence has developed good collaboration with a number of European banks in which doctoral candidates can undertake an internship. In the economic and business management fields, joint projects between academia and industry are based on the use of empirical data from the industry,

provided that the candidate can publish his/her research results. The collaboration is normally based on personal contacts of faculty member to those industries open to doctoral candidates or holders. In this type of project the issues at stake, including IPR, are dealt with very individually. Currently, large companies are really interested in global new approaches and this is also a hot topic in university research, hence it seems there is research ground for cooperation.

However, despite some positive examples, doctoral candidates and holders in social sciences have only limited opportunities to participate in collaborative doctoral programmes. Additionally, university-industry interaction in these areas is very one-to-one, usually neither planned nor structured and seems to happen sporadically and by chance. In this context, talking about structured or organised collaborative doctoral programmes may sound somewhat limiting or imposing. However, 'structure' may mean many things and a good balance of structure and flexibility could be envisaged. The following could be structural conditions to improve university-industry relations in ESS:

- Mobility during the doctoral thesis was considered an important part of the doctoral process because holders with mobility experience seem to be "marketable and highly employable". More attention should be paid to mobility, such as internships of doctoral candidates from social sciences in industry and support of theses focused on e.g. study of social/economic impact of new technologies, innovations, etc. Doctoral candidates in social sciences are often older, with some professional experience, and developing tailor-made internships could be a way to address this issue. Encouraging mobility between the three cycles, meaning a student should be encouraged to do his/her Bachelor – Master – Doctoral studies in different institutions, was seen as a good trend that will enhance employability opportunities and develop entrepreneurship.
- Employability: Hanken case study notes that *"Industry says people in academia are not ready to work for industry but they hire them anyway because they value their skills as doctorate holders."* Enhanced recruitment would probably be achieved through developing more awareness of transferable skills in young inexperienced doctoral candidates and holders.
- Raising awareness of the value of research in ESS (and Humanities): Companies may not yet perceive as valuable research in social sciences and, vice versa, social scientists themselves in general may not try to address companies and businesses.

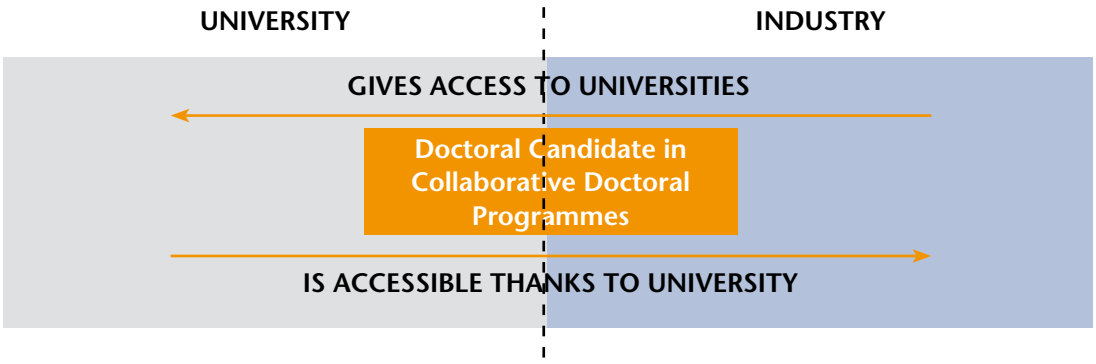
When listening to both communities talking about structural conditions it is clear that the basic problems are not all that different. Certainly, the extent and visibility of university-industry cooperation in the areas of SET and BML is greater than in ESS. Knowledge transfer in SET/BML is also more intense and structured than in ESS: patents, licences, start-ups, spin-offs, research parks, innovation hubs, etc. are focused in SET/BML areas. However, the societal implications of the day-by-day technological advances are huge and their impact difficult to assess. It seems that ESS research permeates to society through channels that are not as obvious and fast as the technological ones. The ways in which the ESS and SET/BML communities talk about and perceive their challenges seem different, but this could just reflect a different stage of development, as SET/BML university-industry cooperation was some time ago. For example, some ESS academics wonder how to raise awareness of the value of their research but SET/BML academics inexperienced in university-industry relations pose the same questions: "Where can I find a company that would be interested in my research?" or "How to find a company which I could help?" Also, it is more common in ESS than in SET/BML areas that people in advanced stages of their careers return back to academia to undertake a doctoral thesis. However mobility issues concerning age, gender, location, family, etc. are common to all fields. Efforts can be made from all sides, academic and industry and policy making bodies to raise awareness and devise solutions for improvement.

3.5. The Doctoral Candidate as a Link between University and Industry

When universities and industries select doctoral candidates for collaborative doctoral programmes, in addition to the minimum academic qualifications required (Bachelor, Master), they look for excellent highly motivated people, trustworthy, and of course interested in research including industry R&D, as was represented in Fig. 3.2-1. This is important because a very relevant role of a doctoral candidate in a collaborative project is that of a link between university and industry to benefit all three parties – university, industry and him/herself – and learning to integrate and operate with different needs, objectives, methodologies and cultures (Fig. 3.5.1). Normally recruited doctoral candidates are early-stage researchers with enrolment and completion of the doctoral thesis within the 25-35 years age band.

> *More than providing well-skilled doctorate holders for business careers, it tends to strengthen and boost relations between universities and companies. It is really the wedding of 3 parts: university, business and candidate.*
>
> Danièle Quantin, Arcelor Mittal

Fig. 3.5-1 Main role of the doctoral candidate as a link between university and industry in collaborative programmes



Source: E. Chassagneux (EIRMA)

There is a very special situation of doctoral candidates acting as links between university and industry and that is when the candidate is 'shared' by several companies. This could be a good solution, especially for SME with limited possibilities to afford the costs and risks of research, but it is also a solution used by larger companies (e.g. Arjo Wiggings). If this is done through an intermediary organisation (e.g. ECRIN), the administrative burden for the companies can be drastically reduced (See Arjo Wiggings detailed information).

3 Doctoral Programmes in Cooperation with Industry: Contexts, Trends and Strategies

Sharing one doctoral candidate between several companies – Arjo Wiggings

Arjo Wiggings uses the R&D services of an association (ECRIN, created by CNRS and CEA) which facilitates links between research laboratories and companies. The idea is that several companies share a single doctoral candidate on a specific research subject of interest to all of them. The group of companies can include competitors. The association is in charge of the salary and administrative tasks. In the case of a patent, IPR is shared. The doctoral candidate reports his/her research results quarterly to the group of companies. According to Arjo Wiggings, this type of partnership is very interesting: (1) there is a real exchange of information on research topics of interest for the company, (2) the candidate will work about 20% to 30% of the time at Arjo, so that he/ she can have access to the machinery. An Arjo researcher is in charge of the candidate and of relations with the association.

Such an approach could be one way for universities to help SMEs have access to research. In exchange, the company would pay a contribution to the university, which would be in charge of the salary of the candidate and all the logistics. Companies would not have to be in charge of administrative tasks and it would be much more flexible. Sharing research results between several companies is a risk but it should not be a fundamental worry for the company if the doctoral candidate works on basic research which would not compromise the competitive advantage of the companies. Sharing doctoral candidates is a good way to share costs and risks.

Source: Arjo Wiggings

3.5.1. Recruitment and Conditions

Attracting Doctoral Candidates to Collaborative Doctoral Projects

Universities and companies promote collaborative doctoral programmes to attract the best candidates. In government-driven initiatives the calls for applications are publicly announced. In individual, university or industry-driven initiatives, some of the companies interviewed prefer to restrict the source of potential names for doctoral candidates to informal channels, through personal contacts in academia or industry. Most of the time it is a question of confidentiality and/or trust in certain professors with whom they have good relations. Other companies, in addition to personal networking, publicly advertise their openings in job fairs and websites. Some companies also go to universities to present their doctoral schemes and have a first impression of possible candidates. The names of well known R&D companies are in themselves a promotion and attract candidates with little effort. As René Duursma, from Corus said: *"They are attractive to students because they are driven by industry"*. Promotional strategies included:

- Informal networking "word-of-mouth" within the institution and through the national and international networks of contacts of academics: all university and industry cases mentioned this and it is particularly important in ESS areas. (e.g. Stora Enso: *"We get candidates through the professors we have in our steering committees and through our university partnerships."*; Arcelik: *"The university suggests candidates to us based on the qualifications of students.")*
- Advertising internally within the university via posted advertisements, intranet advertisements, contacting potential candidates directly (e.g. in Cagliari, Mykolas Romeris, Hanken, UPMC, Simula, Synpo: *"It is not explicitly promoted. It is information that circulates internally in university.")*
- Targeted letters to rectors, to members of scientific or professional networks
- Brochures, websites, the media, including dissemination of research outputs (e.g. Athens, ESADE, CIFRE, Newcastle, Paderborn, ABG, Ministries, Career Offices, Graduate Schools; Renault: "The information is available on

our website. Our contacts in universities also suggest candidates")

- Special Events:
  - Promotion in Career Fairs organised by higher education institutions or in industrial job fairs at local, national or international level. Many organisations use the international events to attract international candidates (e.g. CIFRE, SIMULA, Paderborn)
  - Information days (e.g. Athens, ESADE, UPMC, IBM: "*Our programme is announced in the public IBM website. Also, IBM employees visit universities to present the doctoral scheme.*")
- Offices in foreign HE institutions: in foreign countries recruitment centres are to be established (e.g. Paderborn). These are groups of foreign professors who can recommend talented students from their home country. They are valuable contacts in case of difficulties with legal aspects.

General Conditions of Doctoral Candidates in DOC-CAREERS Collaborative Cases:

DOC-CAREERS cases gave evidence of the following facts and figures about the general conditions of doctoral candidates enrolling in collaborative doctoral programmes:

- **Entry requirements:** As for any doctoral programme, basic academic accreditations are required to enter collaborative programmes. In the 26 collaborative DOC-CAREERS cases the most common academic degree at the time of enrolment in the programme was Master (79%), followed by Bachelor (14%) and Master with professional experience (7%). In all cases the candidate went through additional interviews with the company, to assess motivations, scientific qualifications and ability to fit into the company culture. In those cases where the legal status of the candidate would be that of an employee of the company, candidates also followed the standard internal HR procedures for recruitment.
- **Agreement/Funding:** In all 26 DOC-CAREERS Collaborative Doctoral Programmes the partner university, the enterprise and the doctorate holder signed an agreement or contract, including the basic components mentioned in Section 3.4.1.). As contingency plans from the industry side, all the involved enterprises declared that they guaranteed the necessary funds for completion of the doctoral process in case of any change to the selected scientific priorities.
- **Legal Status:** All candidates in these programmes had a legal status affiliated either as a company/university employee or as a fellow.
- **Dedication:** In SET/BML areas doctoral candidates of collaborative doctoral programmes are full time. In ESS this varied and it was more common to be a part-time doctoral candidate.
- **Placements:** As we have seen above (Section 3.4.1.), placements in industry are one way to immerse the doctoral candidate in the sector. In DOC-CAREERS cases, the doctoral candidate was integrated in one of the business research units in 12 of the 16 companies handling structured placements and in many universities (e.g. UPMC, TU Delft, SIMULA, Bangor), but in many cases he/she was an individual worker using industry facilities and equipment (e.g. Aarhus-Industrial PhD, UPMC, SIMULA, Bangor, and 4 of the 16 companies handling structured placements).

> *Inter-sectoral mobility is very much encouraged and highly valued. It helps to develop trust and very good personal relationships. These factors are basic for good cooperation.*
>
> René Duursma, Corus

> *The intersectoral experience is greatly valued but it is not uncommon to have problems with sharing dedication - university and/or industry may want more dedication from the doctoral candidate - and this can be difficult to deal with.*
>
> Hans Hofmann, IBM

3 Doctoral Programmes in Cooperation with Industry: Contexts, Trends and Strategies

Practitioners in both university and industry sectors stressed that intersectoral mobility during the doctoral project should be stimulated as "a means to an end". This is important to ensure that the placements are relevant and adequate to the development of the doctoral project. Relevant here means that tasks performed in the industry are related to the doctoral research and adequate means that the candidate is placed in a position where he/she is actually working in a research capacity (examples of bad practices in placements would be, for example, overloading candidates with extra tasks or assigning them tasks for which they are clearly over-qualified). Activities should aim at the overall objective of building expertise through doctoral research including full self-awareness of one's knowledge, skills and experience.

- **Completion rates of doctoral theses**

  There is not much precise data collection on completion rates in collaborative doctoral programmes, normally because their records are mixed together with the traditional doctoral programmes. Only government-driven programmes, such as CIFRE and Marie Curie, have specific records of completion in projects where industry was involved. DOC-CAREERS universities and companies working with doctoral candidates in collaborative doctoral programmes in SET and BML areas reported completion rates of 80% to 100% (e.g. UPMC, Newcastle, IBM, Philips, Haldor Topsoe, Microsoft). In these fields, personal circumstances were a main reason for failure to complete, sometimes because the candidate was offered a job, usually with a higher salary. In ESS areas the completion rates varied considerably and so were the reasons reported, such as having the wrong expectations, work overload in present employment when the doctoral candidate was registered part-time etc. Interestingly, only in a few cases was lack of funding a cause of failure to complete.

Examples from the Case Studies: Completion

Despite of the high percentage of completion rate, drop-out can occur, as these cases illustrate:

- *Mykolas Romeris:* "All doctoral candidates at the University are employed elsewhere. The major reason for failure to complete the doctoral process on time is their occupation rather than the doctoral studies themselves. Normally, doctoral candidates can dedicate on average 25 % of their time to doctoral studies."
- *Corus:* "Occasionally we have to stop the process. When it happens, it is usually because of a low level of quality."
- *Microsoft:* "We have drop outs in very few cases. We sign an agreement to ensure enough funding until the end of the PhD thesis."
- *Stora Enso:* Those candidates involved full time all always complete the process. Doctoral candidates who do not complete the process are usually only among those who consider PhD as a part-time 'hobby'."

Source: EUA DOC-CAREERS Project

- **Employment opportunities offered by the host company**

  As it has been mentioned before, doctoral collaborations are one of the means industries use to identify potential employees. DOC-CAREERS university case studies all remarked that doctoral candidates in successful collaborative projects may have opportunities of being offered employment after their studies, but it is clear that no company commits to that at the beginning of the collaboration. Provision of employment opportunities by the host company are generally higher when the doctoral scheme is driven by large intensive R&D industry and generally lower when the scheme is driven by SME or by university. (e.g. Aarhus, Newcastle, Cagliari, Athens, Hanken, Masaryk, TU Delft, Bangor, UPMC, Paderborn, ESADE).

  In some companies, especially in large R&D corporations, doctoral candidates may be considered as employees during the time of the

doctoral research, but with no commitment to keep their position after earning the degree. Some companies do secure employment of doctoral candidates before earning their degree if they are really interested in them. From the 31 companies interviewed during the project, 19 declared they offered employment opportunities after the candidate earned the doctoral degree.

3.5.2. The Collaborative Doctoral Experience – Views of Doctoral Candidates and Holders

Doctoral candidates in general valued positively their involvement in collaborative doctoral programmes. This section reports a representative sample of comments by universities, doctoral candidates and doctorate holders on their experience in collaborative doctoral programmes. Universities, such as Newcastle and UPMC, reported that in general these types of programmes are beneficial for all actors involved (doctoral candidate, university and industry), as they provide added value if properly managed (Section 3.2.; Table 3.2-1). These programmes are also an excellent framework for doctoral candidates oriented to work in the private sector but also want the best scientific education and research training. Some universities, such as TU Delft had found that collaborative programmes reduce the risk of candidates stepping out of the doctoral process because the applicability of their work is more visible. However, sometimes candidates enjoy their research in the business environment so much that they are distracted by other tasks at the company and neglect their own research. Dealing with several supervisors from academia and industry is a challenge, adding additional complexity to the doctoral process.

The following are a few testimonial comments from doctoral candidates collected mainly by EURODOC and from the Newcastle University case study:

Having the right expectations is important...

"I obviously hope to attain a PhD in Chemistry as well as gaining general skills such as report writing, data analysis, presentation skills, teaching skills (through lab demonstrating), meeting deadlines, perseverance in problem solving", doctoral candidate in chemistry.

...access to training…

"Yes, there is abundance of voluntary training available, both technical as well as in transferable skills. It is compulsory that some academic courses are taken during the PhD project and 8 credits need to be attained which is equivalent to four short courses over the three years. I think the training is equivalent with the added bonus of the industrial placement", doctoral candidate in chemistry.

"I have access to the training I need but it is on a voluntary basis. I have the sensation that I have better training than a 'normal' doctorate but only if I search for it", doctoral candidate in engineering and technology.

...access to industry facilities and to industry networks ...

"As part of a Marie Curie Research Training Network, in my project many secondary skills are provided. Connection with industries is really close and different secondments are planned during the three year programme", doctoral candidate in engineering and technology.

"It provides good connections in the business world, giving the student the opportunity to compare with the academic world", doctoral candidate in engineering and technology.

"No problems. Gives access to a network of personnel in my field and a good forum to discuss my work outside of academia. On the whole I have enjoyed the process, mainly due to the collaborating partner relations and those in the field where I have conducted research", doctoral candidate, Newcastle.

...but there are challenges:

"It was hard (still is, just finished writing up) and I underestimated what it would take, but I have learnt a hell of a lot which I wouldn't have done if I'd done a straight academic PhD. Working with a partner organisation both massively enriched the experience but also made it much harder", doctoral candidate, Newcastle.

3 Doctoral Programmes in Cooperation with Industry: Contexts, Trends and Strategies

"Disadvantages - extra work in terms of preparing reports etc. The format required for working reports was not easily transferred for use in my PhD so I felt that I had 'written up' twice. Also, sometimes unrealistic expectations - expecting a full research project that should have a number of researchers working on it", doctoral candidate, Newcastle.

"I think the industrial involvement is beneficial, but there are some complications, for example, when I give a presentation of my work. The presentation needs to be sent to the industrial supervisor approximately two weeks in advance for industry approval, due to the possible disclosure sensitive intellectual property", doctoral candidate in chemistry.

Opinion on joint supervision was generally good…

"My supervisors from industry have a "different" view from an academic professor. The academic supervisor provides me what I need from this side. I think it is a more complete situation compared to the one of a 'normal' doctorate. There are regular reviews, not really frequent, but useful for the progress of the project", doctoral candidate in engineering and technology.

"I meet with industry annually. These reviews are useful as it gives me a chance to take a step back and to see where the project is going and how it is progressing", doctoral candidate in chemistry.

"In having two supervisors, one from the university and the additional benefit of input from a supervisor working in industry, the arrangements are better than that for a normal doctorate. Progress reviews are undertaken annually with the university and the business supervisor is involved. These reviews are helpful for monitoring, identifying training needs and future work", doctoral candidate in natural sciences.

…provided that the non-academic supervisor had the right expertise:

"My arrangements were fine although when the non-academic supervisor changed mid-way there were some problems. The new person lacked sufficient knowledge, skills and inclination to carry on the level of input that my academic supervisors and I felt was contracted and appropriate", doctorate holder in social sciences.

Thinking about improving employability prospects…

"Definitely I feel more employable in non-academic sectors than traditional PhD programmes. Already some positive signs in this direction had been given by industries and partners in my programme", doctoral candidate in engineering and technology.

"I suppose I do feel more employable in non-academic sectors due to the practical nature of my project, it's not simply research for research's sake. I would have thought it was viewed favourably as essentially I'll be getting some experience in the chemical industry, while working in academia", doctoral candidate in chemistry.

…some have proven it can be a reality:

"My guess would be that I benefited more from the CASE approach as I was someone who came to PhD work after a number of years in management. I welcomed the non-academic partner involvement as it bridged the gap between my 'old' world and the new 'academic' one. Initially, because of this, I preferred to work at the non-academic sponsor offices and felt I bonded more quickly with staff there than with other PhD colleagues. Having completed the PhD and returned to full time work, the involvement of my non-academic sponsor also helped me secure the role I now have and opened up networks and opportunities that I would not otherwise have so readily had access to. I always intended to keep working in the non-academic sector", doctorate holder in social sciences.

Despite the problems and difficulties, the most common remark in DOC-CAREERS case evidence from universities, industries, doctoral candidates and other stakeholders was that it had been a very positive experience. The following testimonials are from doctoral candidates:

"Coming from a traditional (corporate banking) work environment it was good to have a non-academic 'home' and 'colleagues' to work with. There were downsides as I may have felt less of

the PhD community because of that. I also did get somewhat concerned about the potential to be drawn into office/organisation 'politics'. However, there were also huge advantages in research terms because I had fabulous access to interviews."

"The non-academic partner offers a chance to get an alternative view on the research and provides additional experience in the real world. I think this is a valuable experience especially if the partner takes a great deal of interest in both the project and the student."

"They are good for the student, the university and the organisation as they provide that crossover contact between theory and practice that is needed to develop projects and ideas in both academia and the real world."

3.6. Recommendations from Stakeholders

Previous Sections 3.3., 3.4. and 3.5. discussed extensively the necessary framework conditions, the partners' challenges when setting up collaborative doctoral projects, when taking them forward, and the special role of the doctoral candidate in the process. Building on these outcomes, this section summarises the recommendations that university experts, industry experts and doctoral candidates, gave to their peers, to the other two stakeholders and to policy making bodies[40]:

Universities to peer universities to prepare the ground for collaborative opportunities in general and doctoral programmes in particular:

- Get commitment from university government and top management
- Develop clear vision of benefits for stakeholders
- Market strategy appropriately
- Start with small projects
- Find partners who value university R&D
- Build research capacity and structure university research in laboratories with strong disciplinary focus
- Identify talented people and care for their professional development
- Raise awareness of potential benefits of collaborative research; what can be expected and what cannot be expected from each partner, university, industry and doctoral candidate
- Build networks and promote building trusting relationships between academia and industry
- Facilitate industry presence in university facilities: conferences, seminars, invite people from industry, academics and doctoral candidates to present their projects
- Identify new challenges relevant for industry
- Show evidence of successful doctorate holder career paths by institutionalising tracking
- Collaborate with other universities of similar size
- Encourage top researchers to develop contacts with industry
- Promote realistic expectations of university research.

Universities to other universities and industry partners to set up partnerships:

- Select partners who value university R&D and are committed to the project and education
- Sign agreements clearly stating rights and obligations of each partner
- Deal with IP rights before the project starts
- Discuss openly problems
- Find balance between boundaries, structure and flexibility
- Deliver good quality research on time
- Raise awareness of the realistic expectations of the project and partnership
- Respect each other's objectives: the doctoral candidate pursues an academic degree, business pursues profit, university pursues academic value
- Be flexible about how the doctoral candidate makes use of his/her time.

[40] The question which addressed recommendations was open-ended. Data available did not allow to report all possible combinations of recommendations.

3 Doctoral Programmes in Cooperation with Industry: Contexts, Trends and Strategies

"The fast track is: great commitment, good coordination and mutual knowledge. One application developed at Newcastle University took two weeks from inception to submission, although this was only possible because we knew each other well, had researched together before, had the time to devote to it in the time available, and things went smoothly."

Newcastle University

Universities to Policy Making Bodies:

- Support the third mission of universities
- Develop competitive funding programmes for the promotion of collaborative relations and to deal with the structural problems of the different sectors
- Promote competent and efficient management
- Grant only good quality research projects to good quality researchers
- Balance funding distribution between areas of knowledge (SET, BML, ESS) and industry sectors.

Industries to university:

On education:

- Provide broader views – interdisciplinary, applications of tech developments
- Conduct research in industrial facilities
- Raise awareness of industrial mindset.

On management:

- Improve knowledge transfer expertise and management
- Improve process decision making
- Formulate clear agreements, specially on IPR.

Industry to peer industries:

- Formulate clear agreements, specially on IPR
- Establish roadmaps for long-term research strategy
- Select doctoral candidates carefully
- Have a clear duty to students, commit to supervision, build relations with university supervisor.

Doctoral candidates to university and industry:

- University and industry partners should have strong interest in and sense of commitment to the doctoral candidate and the project (effective supervision)
- Make all partners aware of each other's realistic expectations
- Define clearly and early enough the roles and responsibilities of each party and the 'rules of the game' to minimise conflict situations during the research period
- Be flexible, taking account of the dynamics of the relationship and the interest of doctoral candidate
- Acknowledge the different dynamics of the partners and contribute to smooth out difficult situations.

Use of "good practice" guidelines for university-industry cooperation

Many DOC-CAREERS cases were aware and used good practice guidelines in establishing university-industry cooperation in general and in doctoral education in particular. The "Responsible Partnering Guidelines" and other national, institutional or organisational guidelines or ethical codes were mentioned by many (e.g. Athens, ESADE, Newcastle, Mykolas Romeris, UPMC, Paderborn, BANGOR, IBM, Solvay, Schlumberger, Renault, Biocydex, P&G). Some universities (e.g. Newcastle, UPMC, Mykolas Romeris), as part of their own institutional good practice include guidance seminars and workshops where faculty, staff and candidates experienced in collaborative research share their views and lessons learned during application processes and actual development of the activity.

Examples from the Case Studies: Industry recommendations

- *Corus:* "I recommend universities approaching Knowledge Transfer from a wider perspective and puting in place the right infrastructure, well trained people and adapt governance systems to speed up process decision making."
- *Infineum:* "Educate PhD candidates in an environment of teamwork. Provide broader education – or capacity for broader views, applications. Conduct part of the research in-company. This needs an evolution in mindset. Establish secondments in companies for students and doctoral candidates."
- *Oridis Biomed:* "Take into account the different mindset in academia and business. For universities, to come up with an idea is an end point but for industry the idea is just the starting point."
- *Renault:* "Business should establish a road map for long-term development. Select candidates appropriately: look for motivated people. Provide good supervision: commit to the supervisory work and establish supervisory teams with people from academia and industry to balance input from both worlds."
- *Procter & Gamble:* "Make sure that the IP agreement is signed with the university, have a clear duty of care for students, open relationship between supervisors."
- *Biocydex:* "Promoting fundamental research to maintain and produce innovation is economically crucial if the fundamental research and the industrial needs are synchronised."
- *Dow Corning:* "We usually partner with universities with which we had links in the past and which are reliable. We are interested in the research background of fields we want to expand. We are attentive to macro-trends in the world, relevant patents and articles, and then we contact the authors."

Source: EUA DOC-CAREERS Project

Examples from the Case Studies: University Recommendations

- *TU Delft:* "Respect each other's objectives: for businesses that is making a profit, for the university it is producing academic publications; Base long-term partnerships upon the experiences acquired during smaller joint research projects. This approach allows both sides to learn about each other and what each has to gain from the relationship; Research capacity is a more common problem than lack of money, because there are too few people of sufficient quality available."
- *Paderborn:* "First, the decision to set up such a programme has to be made and be strongly supported by the top management of the institution. Second, there should be a clear vision how the involved persons/groups/institutions will benefit from the programme…"
- *UPMC:* "In France, the CIFRE scheme seems to ease professional integration of candidates who have been involved in it and satisfies all partners. But as already mentioned, the scheme is built for, and consequently chosen by, actors who know exactly what they want and what they expect from it. That is undoubtedly the main key of its success. Besides this important point, the strengths of the CIFRE scheme, according to us, rely on: i) its nation-wide dimension with a unique and well defined policy; ii) coupled with/ sustained by the existence of a specific and competent body to manage it on behalf of the ministry; iii) the strict selection process of the three types of actors; iv) the existence of the three types of contracts which separate and clearly distribute roles, responsibility and commitments. Its weaknesses, could be: i) uneven distribution of funds across sectors; ii) the limited information about the actual positions and career paths of doctorate holders."
- *Newcastle:* "In the social sciences and the arts and humanities, funding support is necessary in order to make possible collaborative studentships. Many relevant non-academic organisations simply would not have the money to consider funding a studentship themselves."
- *Hanken:* "The most important thing is to build strong and long-term relationships between the University's top-management, senior faculty and the corporate world based on mutual trust. The output from academic research conducted by senior faculty must be valued by the corporate world and disseminated appropriately. Only then can doctoral education, including funding of doctoral students, be another of the activities in cooperation with corporate world."
- *Athens:* "In the absence of sustainable public (national or institutional) funding mechanism for PhDs, then a key success factor is a broad networking activity and a strong scanning activity of relevant national and international calls for research. Structuring research in labs with strong disciplinary focus and strong integration of PhD candidates is also important."

Source: EUA DOC-CAREERS Project

3 Doctoral Programmes in Cooperation with Industry: Contexts, Trends and Strategies

3.7. Monitoring, Impact and Sustainability of Collaborative Doctoral Programmes

Monitoring collaborative doctoral programmes:

Some DOC-CAREERS **university** cases mentioned they used formal or informal monitoring to assess the impact of doctoral programmes in general and collaborative doctoral programmes in particular. Methods of monitoring processes included:

- Testimonial
- Follow-up through a set of indicators chosen by the institution
- Surveys/Structured evaluations either within the university only or with the university and industrial partner
- Tracking of doctorate holders (Chapter 5).

In general, monitoring systems of doctoral programmes in **universities** were not fully institutionalised. In some cases monitoring schemes had been part of institutional strategy for a while but not systematically, and the periodic assessments depended very much on resources available. However, general opinion was that institutional monitoring should become normal practice and part of the institutional strategy to inform curricula and profile of the university. On their part, **companies** so far are mostly interested in the doctorate candidate/holder gaining the necessary expertise to contribute well towards the project. Hence, they limit assessment to purely testimonial or indirect assessment of individuals (for example, it was a success if a former doctoral candidate is hired by the host company). As TU Delft explained *"Success is measured by i) willingness to continue running the programme in the view of positive assessment of research and partnership; ii) continued interest from candidates to joining the scheme; iii) continued interest from academics in supervising candidates on the scheme."*

Assessing the impact of the scheme on the doctoral candidate, the university, the business and the city/region:

In general terms, the impact of collaborative doctoral programmes in terms of facts and figures was difficult to measure but many qualitative trends were highlighted. Comments were basically positive on the impact of collaborative doctoral programmes at many levels: individual, institutional in the case of universities, organisational in the case of industry, and also local and sometimes even international. The sources of the comments below are a collection of remarks provided by the majority of the DOC-CAREERS university and industry cases, including a detailed assessment conducted by UPMC:

On the negative side:

- If things go wrong … bad reputation for all, potential negative consequences for the doctoral candidate, and reinforcing the typical mindset "universities are not good to work with industry".
- Potential hostility from those universities who uphold the old system (e.g. in evaluation committees).

On the positive side:

- General impact on the city/region and international environments:
  - o Enhancing attractiveness of the city/region in general and for young researchers in particular
  - o Contributed to innovation in products, services and processes through research, which made an impact on the economy and cultural activities in the city and the region
  - o It helped to build stronger university-industry relations in general
  - o Building regional synergies to create communication forums, identifying challenges and coordinating funding
  - o Opportunity for the development and upholding competitiveness of regional SMEs
  - o Creation of employment
  - o Keeping companies in the city region

- On doctoral graduates:
  - o Broader employment perspectives for doctoral graduates, especially outside academic environments.
  - o Better awareness of the broader employability opportunities for doctorate holders
  - o Understanding the industry research environment
  - o Embedding industrial mindset as well as university mindset in his/her education
  - o Able to deal easily with the two worlds because of better understanding
  - o Those who follow a subsequent academic career path can inform academic curricula development
  - o Improving CV: when looking for employment, doctorate holders take with them the good reputation of the scheme that funded their research and/or the name of the company and university in which they worked.
- On the non-academic partners:
  - o Enhances cooperation with university
  - o Development/increase of credibility to shareholders and venture capitalists, especially for start-ups
  - o Raise awareness of skills and qualifications of highly skilled professionals
  - o Opportunity to educate fit-for-purpose employees with a high level of technical skills
  - o Increase in revenue in the long term, improvement in services or in management
  - o Realising the evolution of the attitude of the universities towards industry
  - o Brings solid background knowledge to industry
- On the university (and related institutes or laboratories):
  - o Make university-industry cooperation a part of normal activity in university
  - o Enhancing doctoral studies appreciation and increased number of doctoral graduates
  - o Improving university-industry relations in general
  - o Raise of awareness of the importance of basic research
  - o Enhanced opportunity to detect scientific challenges in industry sector
  - o Improving institutional profile and outreach
  - o Attraction of more funding for research and for doctoral candidates, which in its turn enhances autonomy
  - o Attraction of students from other regions and internationally
  - o Creation of interdisciplinary teams including researchers from the academic and non-academic sector
  - o Enhancing mobility
  - o Enhancing reputation of institution
  - o Better records in research assessments
  - o Doctoral graduates from collaborative programmes can bring more contacts form industry and also inform academic curricula.

3 Doctoral Programmes in Cooperation with Industry: Contexts, Trends and Strategies

Examples from the Case Studies: Impact of collaborative doctoral programmes

- *CORUS:* "These scheme has a very large impact in our region. It opened the eyes of the university to needs of the industry and viceversa. It provides constant benefits for both sides."
- *IBM:* "The existence of this scheme is definitely an opportunity for the region: we attract the best people. For the city-region we create a good environment. It is a win-win situation."
- *Solvay:* "We are good employers for the region; cooperation with academia not only improved our capacity of innovation but also increased our profile vis-à-vis the local authorities. To the doctoral candidate it allows him/her access to both worlds - academia and industry. To the university: it facilitates the development of contacts with industry and applied research. To the business: it improves access to academia, e.g. academics acting as consultants for the company."
- *Bangor:* "It is too soon to measure the impact (turn over, jobs created, etc.) but the number of PhD candiates has increased which is already a success. Research capacity and critcial mass of projects in cooperation with industry is growing. To modernise higher education, coooperation with industry is essential."
- *Newcastle:* "The impact on the non-academic partners varies, according to the success of the particular studentship. The impact on the student is variable also but there was consensus that the added experience gained through working on a collaborative studentship, when it was successful, was invaluable both in terms of personal development and employability. If the collaboration was not successful, then the studentship reverted to a traditional, non-collaborative PhD."
- *ESADE:* "Scientific research leads to innovation in products, services and processes. Management of research and research teams is a crucial point in innovation and globalisation and internationalisation is transforming the managing practices of companies."
- *Aarhus:* "The industrial PhD has been all in all a positive experience for us and it is important to state that the same ordinary PhD rules, regulations and academic standards apply."
- *Athens:* "The impact is a positive impact for all parties involved. It enhanced university–business collaboration; it builds bridges. For the PhD graduate, it is undoubtedly an advantage in the job market to have been a recipient of a PENED scholarship."

Source: EUA DOC-CAREERS Project

Prospects for the sustainability of collaborative doctoral schemes:

Views on sustainability prospects of the doctoral schemes varied very much in DOC-CAREERS cases. Their answers to the question on the sustainability perspectives of the initiatives in which they participated included:

- Sustainable subject to positive evaluation by the company/funding body
- Sustainable subject to availability of external funding public or private
- Sustainable because the scheme is based on many collaborations with different companies
- Depends upon the performance of the university, that is, how able it is to demonstrate added value and create sustainable opportunities for cooperation.

Sustainability of individually-driven, university-driven and industry-driven programmes depending on public funds (especially for SME) is normally linked to public funding support. Large R&D-oriented companies may be less dependent on public funds but many still insisted this support was necessary. Provided that a collaborative doctoral programme is successful, it seems that the longer the programme runs, the easier it is to keep it running. This is the case of the government-driven initiatives studied in this project, such as CIFRE, CASE or Danish Industrial PhD. These initiatives can create a "brand" and enter a virtuous circle in which the good outcomes of these programmes reinforce their good reputation. This trend is also common in large R&D-driven initiatives, and they all aim in principle at continuing to run their programmes. Some universities partner only with well-established large R&D companies because they think funding of the programme is safer in terms of sustainability. Others ensure their sustainability by working with many partners, thus diversifying the risks.

4 Employability Perspectives, Mobility and Skill Requirements

Doctorate holders are people who have been specially educated and trained to conduct research. Traditionally, doctoral education takes place immediately after earning a Bachelor or Master degree but the process can also start at later stages of professional development, e.g. after the candidate has worked for some time in the labour market outside higher education institutions (an increasing minority undertaking 'professional doctorates', where the research project is related to their professional practice). The doctoral process is seen as a unique life time experience and normally influences not only the professional but also the personal development.

Not all can expect or want to work in the academic sector: many are employed in non-academic organisations. In fact, candidates may be genuinely interested in a non-academic career, but still want to receive the best possible training in their field. Often people speak of doctorate holders moving to the industry sector as if this latter was a second-class choice, less glamorous than academia, or a sort of failure. This mindset needs urgent adjustment and an evolution towards more open views on how doctorate holders can use their attributes to serve better in the labour market and society. In general, professors and doctoral candidates should be persuaded that the careers of doctorate holders both in academic and non-academic environments are legitimate first choices, and that the skills needed to carry out research also equip the doctorate holder to perform other types of work. The specific skills and competences that they acquire through research during an average time of 3 to 5 years will also enable them to pursue other career paths outside and within the academic environment.

Beyond the specific education and training related to their research foci and methodologies, other values embedded in their mindset during the doctoral process can enhance their career options, be they in or outside academia (Section 4.4.). These include, for example, critical thinking, rigour and drive to have in mind the "breadth and depth" of a problem, that is, to place very specific problems into context. Doctoral candidates should be prepared to face the challenges associated in dealing with different cultures of different sectors because even if they 'stay' in academia, they will be unavoidably exposed to other environments. The culture shock between business and academia is a strong and obvious one but there are also less visible – at least less outspoken – culture shocks when moving between HE institutions, particularly internationally but also within the same country, or between university and government bodies, for example. In the end, doctorate candidates/holders have an opportunity to make their career choices. Those who go into industry after holding exclusively academic positions may not be adequately prepared to face the culture shock. This can overshadow their stronger skills and competences, at least while adjusting to the different working timeframes and dynamics, making them appear as 'out of touch with reality' to the eyes of other colleagues and managers.

Since doctorate holders will face different mindsets and 'realities' no matter in which sector they develop their careers, it is worthwhile for universities, through their doctoral programmes, to take the lead in raising awareness, where feasible, of the main career options and issues that doctorate holders may encounter, without overloading the candidate's time. The responsibility to educate good researchers lies with the universities themselves and they can also provide additional seminars or courses to raise general awareness of career options and the skills valued in the different sectors (Section 4.4.).

The views expressed by DOC-CAREERS universities, industries and other stakeholders concurred that career paths of doctorate holders in research and non-research positions are extremely diverse, in both academic and non-academic organisations. Except for a few trends in academia or in industry, it is very difficult to talk about doctoral career typologies. Even more, by doing so, there is a risk of encapsulating views and options unnecessarily. It is more appropriate to talk broadly about the career or employment opportunities that are open to people who have been highly trained in the methods of research. In this sense, institutional tracking of the professional destinations of their doctoral graduates can prove of great value to universities to inform curricula and develop better their specific missions and profiles in doctoral education. By reinforcing links with doctoral candidates before leaving university and by establishing appropriate tracking methodologies, universities can have access both to particular information on careers and to global institutional information.

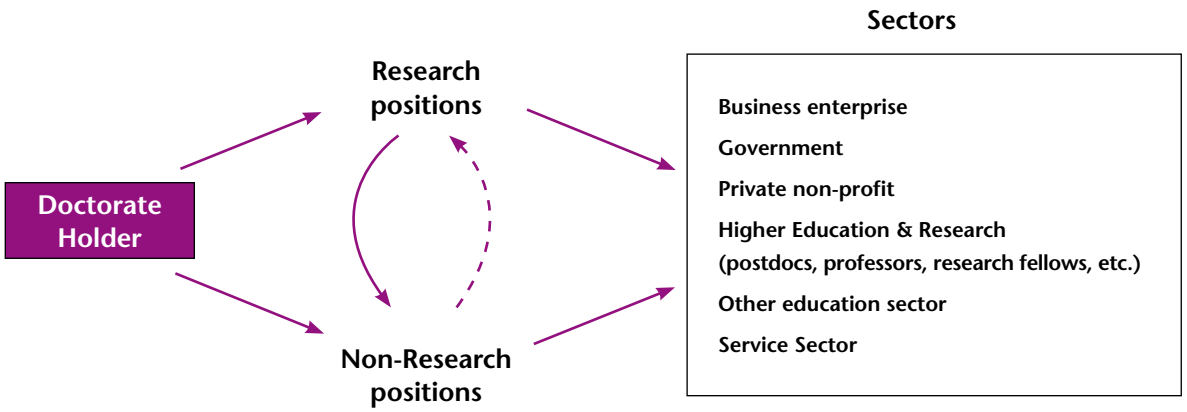
4 Employability Perspectives, Mobility and Skill Requirements

4.1. Employability and Mobility: General Trends

Employability and mobility are intrinsically linked in doctorate holders' careers, because of the increasing value that mobility has for both university and industry sectors, especially in high level positions. The value of mobility lies in the exposure to different environments and in the benefit that the person gains from learning and playing different roles, interacting with different people and building up his/her own network of contacts. In this context there are two broad types of mobility: within academia or within industry (intrasectoral) and between academia and industry (intersectoral).

Despite the current efforts to reduce barriers between university and industry, the reality is that mid-career moves between academia and industry are not easy. Special cases are those industrial doctorate holders who hold part-time academic positions. Fig 4.1-1 shows synoptically a framework of career options: Doctoral graduates can opt for a research or a non-research position immediately after earning their degrees or at a later stage in their careers, within academia and outside it. While it is always possible (at least in principle) to move from a research- to a non-research-oriented job, a move in the other direction is less straightforward, because of the difficulty of re-engaging in state-of-the-art research after a certain threshold time, especially in SET and BML areas. Although lack of data makes it difficult to generalise this kind of statement, it is the general view and experience expressed by many stakeholders. Furthermore, a doctorate holder who has made a substantial commitment to further academic research by pursuing post-doctoral positions may not have been able to gain the broader skills and experiences required in senior positions outside research.

Fig 4.1-1 Synoptic view of career options for doctorate holders



Source: EUA DOC-CAREERS Project

What DOC-CAREERS cases demonstrated

When universities were asked if they considered that doctorate holders graduating from collaborative schemes were more employable in non-academic sectors compared with those graduating from the more traditional ones, the general response was 'Yes, but…', and the 'buts' included:

- Yes, in research-oriented companies
- Yes, but it depends on the person: industry is usually a second option especially for those graduates with a more theoretical orientation
- Yes, if interaction with industry was frequent and continued during the development of the thesis
- Yes, but those candidates who enrol in these types of doctoral programmes normally aim at pursuing a career outside academia from the beginning.

Other universities thought the difference on employability was not especially significant. Nevertheless, they had testimonial evidence that the integration of doctorate holders in business environments after a collaborative project had been easier (e.g. Masaryk, Mykolas Romeris, Newcastle, TUDelft, Paderborn). A general comment was that even if the doctorate holder had stayed in academic environments, he/she could provide a valuable link for collaborations with the industry world.

Some DOC-CAREERS university case studies provided data on employment destinations of their doctoral graduates between 2004 and 2007 (Annex 7.4). The employment outcomes reported are not strictly comparable because every university collected and structured their data in an individual way. Employment figures clearly show significant percentages of doctorate holders being employed in the business-enterprise sector, government, and in the service sector, both in research and non-research positions.

The proportion of doctorate holders from collaborative programmes with strong involvement of industry indicated a high proportion of employment outside academia, for example, 38% in TUDelft-TRAIL, 70% in Paderborn-PACE and 70% in UPMC-CIFRE. These are programmes in SET and BML areas but doctorate holders from ESS fields also are employed in industry, both in research and non-research positions, such as the cases reported by ESADE and Hanken Swedish School of Economics. The most typical case in the ESS field is that reported by Mykolas Romeris where all doctoral candidates are employed in enterprises while doing their doctoral studies. Specific details of employment destinations are given in Annex 7.4.

When **companies** were asked about the employability of collaborative doctorate holders in the industrial sector, the unanimous response from those who participated in collaborative doctoral programmes was that, indeed, they are more employable (e.g. Biocydex, Corus, IBM, Microsoft, P&G, Renault, Philips, etc.). Moreover, they think that normally these graduates are well prepared to develop successful academic as well as non-academic careers, because they have embedded in their mindset academic standards and business experience. Amongst the most valuable business experience of these doctorate holders, companies highlighted the 'bridging' nature of these doctorate holders (e.g. Philips) and the intellectual property awareness (e.g. Solvay). Some companies even hire doctoral candidates as staff before they complete their doctoral thesis, e.g. P&G or Lafarge. Other companies did not offer strong opinions but emphasised that it depended very much on the quality of the candidate and how he/she fitted in the company (e.g. Schlumberger, Synpo).

It is clear that companies have different expectations of researchers and ask for different credentials than universities. DOC-CAREERS studied what companies expected from their researchers, what doctorate holders did in a company, if they were satisfied with their performance and if they thought doctorate holders enjoyed working in their company. The following sections of this chapter analyse their views on these questions related to their particular contexts.

4 Employability Perspectives, Mobility and Skill Requirements

4.2. Employability and Mobility: Companies' Views

This section describes the outcomes of the interviews conducted with CEOs, Heads of R&D departments or Human Resources departments of R&D European-based companies, mostly EIRMA members. Company profiles were reported in Section 2.3.

Expectations

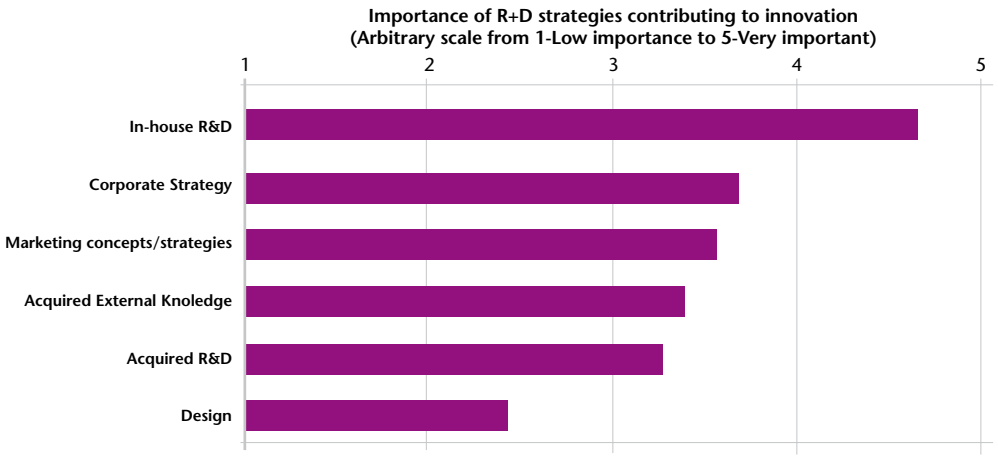
Several of the companies interviewed not only expect a researcher to be exceptional in science but he/she also needs to be aware of the potential commercial output of his/her research. If, in the past, industry competitiveness was focussed mainly on the technology push, nowadays, the concern is to achieve more broadly-based marketable innovations. The capacity to innovate is seen as a main competitive advantage for most companies and it is essential to achieve a high return on their R&D investment. For this reason, a researcher in such a company needs to understand how to translate research into products that take into account market potential, main challenges, corporate strategies and customers' needs.

> *We link Doctoral Programmes to the development of technology and raw materials. We seek dialogue with stakeholders to guarantee our sustainability and it is a part of our policy in dealing with universities.*
>
> Jukka Kilpeläinen, Stora Enso

However, larger or high technology-oriented companies normally have the means to divide scientific and technical activities across their organisation. Doctorate holders working in basic research in such companies are likely to be evaluated primarily on their technical capacities, originality and creativity, and the company will be less concerned with their general managerial competencies or their ability to reconcile their research activities with the needs of customers.

Several of the interviewed companies were conscious of the importance of keeping researchers in fundamental issues and free, as far as possible, from immediate business constraints. For example, Olivier Peyret, from Schlumberger explained that they recruited some researchers who had left

Fig. 4.2.1-1 Enterprise strategies contributing to Innovation



Source: EUA DOC-CAREERS Project

their previous companies because they wanted to remain in research and not move into managerial positions. In a company such as Arjo Wiggings, E. Buhannic highlighted that most researchers really like research and want to keep to a research career. However, C. Hautin Ferrero, from L'Oréal noticed that basic researchers who are conscious of customers' needs are in general, more creative. Researchers working in more applied areas of R&D are expected to be both good researchers and good managers.

In line with the trend towards more "open innovation" many of the companies interviewed are recognising that the skills needed to integrate scientific knowledge from different sources are not necessarily the same as the skills needed to generate that knowledge in the first place. The ability to cross technical boundaries, i.e. technical breadth, is a sought-after, and seemingly not easy to find, skill.

However, expectations vis-à-vis researchers differ from one company to another and depend on company size and sector. SMEs or companies with a limited budget for R&D do not only expect the researcher to be solely a good scientist but also a good manager, able to communicate with non-specialists, customers, etc. The following sections explore industries' views on their strategies for innovation and, according to them, what they expect from researchers and how they select them.

> ***"Turnover can be unhealthy if it is too high but it can be also very harmful if it is too unusual. For us, 10% of researchers need to move from one position to another. It is very important to integrate new ideas in the company. Optimal turnover should be achieved not only internally but also integrating people from the outside."***
>
> Jean-Yves Colombel, Thales

4.2.1. Strategies for Innovation

Companies draw-up R&D human resources policy according to their ways and means to innovation. To understand better their recruitment policies, companies were asked first to rate the importance they attributed to strategies for innovation[41] using a scale from 1 (low importance) to 5 (high importance). Fig. 4.2.1-1 shows that, in average, the main contribution to innovation came from in-house R&D. Corporate strategies, marketing strategies, acquired external knowledge and R&D were all rated medium to high importance; strategies on design were considered the least important. This panorama is generally in line with the innovation profile of the companies (Fig. 2.3-1), which validates the methodology used to estimate the innovation index of the companies (Annex 7.5). For some companies, collaborative doctoral programmes are seen as being key to developing their innovation capacity, as reported by Schlumberger, Renault or Stora Enso, among others.

4.2.2. Approaches to the Recruitment of Doctorate Holders

The interviewed companies recruit doctorate holders in ways and numbers which depend on the company size and R&D investment. In the DOC-CAREERS company case studies the proportion of doctorate holders in R&D ranged very broadly from 20 to 70% of the R&D Staff. One of the basic missions of a human resources (HR) department is to ensure that the staff personnel have the competencies required to achieve the company objectives of today, tomorrow and in the long term, and HR departments strive for the development of profiles and recruitment policies capable of meeting thes foreseen challenges. In the selection of research personnel, the R&D department is responsible for ensuring that the applicant has the appropriate scientific and technical qualifications for the position, and will take the decision to recruit or not. Although procedures and tools differ from company to company, some interesting tendencies emerged from the study.

41. Based on DTI n.9 Report, 2006

4 Employability Perspectives, Mobility and Skill Requirements

a. Human resources policies

Attracting and retaining good employees is essential for a company. High employee turnover becomes an issue when key knowledge that goes along with human capital is lost, thereby affecting the company's sustainability. However, R&D departments have distinctive characteristics from others, especially in high-technology oriented companies, because their contribution derives from understanding breakthrough ideas and having the creativity and originality to translate this understanding into better products and services. On one side, a good turnover can boost these characteristics by incorporating "new brains" with "fresh ideas" in the research teams. On the other side, long-term or permanent job positions also provide a stable framework for good employees to foster their creativity, dedication and follow-up of projects through the years. Large R&D-oriented companies often offer interesting contract conditions to their researchers for them to stay in the company. The fidelity of researchers is the asset to keep knowledge and know-how in-house, creating thus a corporate culture. Companies can estimate what the optimal turn-over is for them, as the case of Thales, for whom an appropriate annual turnover rate is around 10%.

Some high-tech companies have developed tools to value technical and scientific competences, along the same lines as normal practice in management positions. Schlumberger, for example, set up a specific system of promotion for researchers to let the best employees develop a research career within the company by planning a dual-ladder scheme in parallel to the classical managerial one (see Schlumberger detailed information).

These kinds of policies support medium to long-term company strategies and enhance bonds with universities to ensure access to cutting-edge research. Normally, these companies establish solid and long term collaboration with key universities, i.e. universities conducting excellent research in their relevant fields, which enable access to well-educated people with the attributes the company is looking for. This is, for example, the case of Lafarge which established a joint programme with two French universities (See Lafarge detailed information).

In addition to these kinds of initiatives, some high-tech companies are tackling the apparent growing scarcity of European students interested in scientific and technical careers by building durable relations with the whole education sector, starting from primary schools. Some companies organise events to raise awareness of science and technology. For example, L'Oréal organises the annual "Village de la Chimie" (the "Chemical Village") where company engineers and researchers meet young pupils and their parents and show them what they do in their jobs. In secondary schools, Schlumberger has set up the Seed programme (Schlumberger Excellence in Educational Development). To promote sciences in developing countries, Schlumberger sponsors classroom furniture, educational material and IT equipment for science, teaching and learning.

Creating an University-Business Educational Joint Programme - Lafarge

To have access to highly-skilled people, Lafarge created a Chair with two leading French Engineering Schools: L'École Polytechnique de Paris and l'École Nationale des Ponts et Chaussées. Lafarge selected them because they can provide employees with the specific skills and competences they need. Lafarge contributes with funding, participates in the selection of thematic orientations and welcomes internships of second-year-master students. Scientists are quite free to organise their research within a framework provided by Lafarge. This system combines steering with flexibility. The Chair has a very high scientific level and integrates six disciplines (amongst them chemistry, physics and sustainable economy) and trains students through teaching and research. It attracts students from all over the world. The Chair also sponsors doctoral theses, post-doctoral researchers, organises seminars, and cooperates with other HE institutions outside Europe (e.g. MIT, University of California, Berkeley). The Lafarge Chair sponsors 5 to 6 doctoral students each year.

Source: Lafarge

b. Recruitment of doctorate holders

Fields of Knowledge

In the DOC-CAREERS sample of companies, the distribution area of knowledge of recruitment was as follows: Engineering and Technology (41,5%); Natural Sciences (31,5%,); Medical Sciences (14,5%); Social Sciences (11,5%) and Humanities (1,0%). This distribution is characteristic of the engineering and technology sector in which most of the participant companies belong. For some companies, the fields in which they recruit research experts evolve over time, as they open new areas of business (e.g. Eric Buhanic, Arjo Wiggins, said: *"In general, we hire doctorate holders in engineering and technology, but in line with the new group's strategic development, we also hire researchers in biochemistry and nanotechnology"*). Some of these companies exceptionally recruit doctorate holders in humanities and social sciences, especially when developing products which involve behavioural changes of consumers or societal concern (e.g. driving electrical cars or handling new generations of mobile phones).

Approaches to recruitment

The recruitment of a doctorate holder may be a spontaneous result of a general recruitment process, where a candidate with relevant skills and experience for a position happens to have a doctoral degree. But companies also decide to recruit doctorate holders specifically. Participant companies were asked to identify their approaches to recruitment of doctorate holders amongst four suggested options. The aim was to know if the recruitment was more or less targeted and if there were perspectives of long-term career development within the company. The four approaches to recruitment were:

- A1: As an explicitly-distinct group of highly skilled people with potential long-term career perspectives within the company. This meant that they are a community within the company and that they can develop a long term career in it.
- A2: On a case-by-case basis with long-term career perspectives within the company: the company recruits doctorate holders only for particular vacancies, still with potential long-term career perspectives within the company.
- A3: On a case-by-case basis: the company recruits doctorate holders only for particular vacancies with no specific career development opportunities within the company (in principle).
- A4: As part of the general graduate recruitment procedures and potential long-term career perspectives within the company: the company employs primarily Masters and Engineers with no distinctive approach to doctorate holders. Those recruited have the possibility of developing a long-term career within the company.

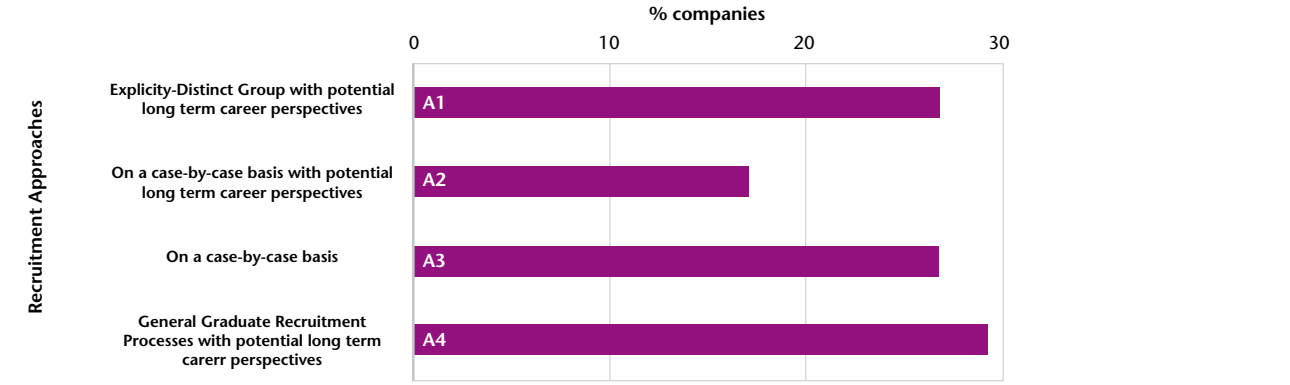
Most of the companies interviewed targeted doctorate holders as part of their regular HR strategy and one third of the companies followed a combination of approaches. Fig. 4.2.2-1 shows the breakdown of approaches by presenting the percentage of companies using each approach[42]. The graph indicates, for example, that 27% of the companies recruited doctorate holders via approach A1, that is, targeting them as an explicit distinct group of highly skilled professionals with potential long-term career perspectives within the company.

Overall, two general trends can be observed: i) that doctorates are indeed targeted as a distinct group of highly trained people (Approaches A1, A2 and A3 amount to 71%); ii) that doctorates are usually recruited with long term career perspectives (Approaches A1, A2 and A4 amount to 73%, as opposed to Approach A3 which amounts only to 27%).

[42] Data were normalised as companies could mark more than one approach according to their practices.

4 Employability Perspectives, Mobility and Skill Requirements

Fig. 4.2.2-1 Approaches to recruitment of doctorate holders



Source: EUA DOC-CAREERS Project

Examples from the Case Studies: Impact of collaborative doctoral programmes

- *Corus:* "We are a metal-making company. Metal sheet is a commodity that we sell to other companies. We hire people for a long time. For those who stay for 10 years or more in the company, we let them do their thesis if they wish."
- *Arjo Wiggins:* "At the moment, doctorate holders are recruited on a case-by-case basis, according to needs and opportunities. In the future, the company plans to set up a recruiting policy with Schools/Universities, in order to attract highly-skilled people to the paper industry. Indeed, in general, doctorate holders are not very interested in the paper industry, which they consider as not sufficiently dynamic."
- *Arcelik:* "Since the beginning of the 90's, Arcelik has special partnerships with universities. We interview graduate students and offer those selected the opportunity to do a Master thesis (1 or 2 years). They may be hired or not after that, depending on the quality of their work (in general, 98% are hired). They normally will work in research, product development or production. For those in R&D department, Arcelik urges them to continue their studies in order to obtain doctorate degree and, in this case, Arcelik provides the necessary support (financial, scientific advice…) for about 4 years."

Source: EUA DOC-CAREERS Project

Companies also reported that for some R&D positions a Masters qualifications may be sufficient (Approach A4). In these cases, if a good applicant happens to have a doctorate degree, it is an additional value. *"We don't look specifically for doctorate holders. We look generally for Master in Sciences. If candidates have a doctorate degree, it is a plus and they can more easily reach positions which require leadership in a technical area", said A. Lowek, SCA; and Jukka Kilpeläinen, from Stora Enso: "Master and PhD count the same for us. We look for the experience and achievements that suit the position".*

c. Challenges in recruiting

In general, scientific and technical qualifications of doctorates are excellent. This is the unanimous opinion of the companies interviewed. Half

reported no particular problems in finding a sufficient number of qualified candidates for their R&D vacancies with respect to other profiles. The most common challenge related to the shortage of applicants in certain fields (e.g. material science, physics, computing, natural/medical sciences, electrochemistry), even though the well-known firms are natural poles of attraction and can recruit worldwide. Some firms report that they do not have such problems in their field currently but they foresee that it may become a problem in the future. This concern is one of the reasons why large companies collaborate with primary and secondary schools. These company experiences reflect, therefore, the statistical data in a recent OECD report indicating the decline in science and engineering graduates[14].

An additional challenge is related to the difficulty of finding experts who fit in with the company culture or future direction. The capacity of the doctorate holder to integrate in the culture and values of the company, and the approaches it seeks to promote as part of its business development, may be as important as his/her scientific and technical profile (e.g. Infineum, Corus). This is a problem for companies working in very specific fields of knowledge which look for 'life time' employees, for those seeking to recruit worldwide, and for those engaged in significant changes in business processes and priorities.

Smaller R&D-intensive companies explicitly reported problems because they need employees who, in addition to being technically and scientifically proficient, already possess other attributes at the moment of recruitment, such as communication skills, ability to speak sensibly about technical issues to a wide range of professionals (clients, production line, sales, purchasing, marketing, distribution, etc.). If, in addition, these companies are regionally/nationally oriented, they will need people fluent in foreign languages to have international outreach, and that is still a problem in some European countries.

d. Employment opportunities for internal doctoral candidates

Companies regard their sponsoring of doctoral studies as one way to gain access to people who will eventually have precisely the high skills that they need: sound research background, industry experience and relevant expertise. It is common for companies with R&D centres in different locations in the world to arrange placements for doctorate holders abroad, in a sort of industrial post-doc so they can gain international experience while consolidating themselves as autonomous researchers. There is no guarantee at all at the beginning of the doctoral studies that all this can happen but companies seek to achieve this with the best performing candidates. Examples of this practice are companies such as Haldor Topsoe, Novo Nordisk, SCA, Arcelor Mittal, P&G, Renault and Philips. Employment opportunities offered by host SME companies depend very much on each case. Further information on skill requirements for doctorate holder at the moment of recruitment is given in Section 4.4.

4.3. Mobility

As was said in Section 4.1., the distinctive characteristic of mobility is that it provides exposure to different environments and different roles within a coherent professional career context, thereby enriching the professional experience and making the candidate more employable. It is very common that highly educated people become mobile professionals: intra-sectoral, inter-sectoral, inter-national, etc. Although the determined duration of an academic employment contract and corporate restructuring may force mobility, for many people, mobility is actually a choice which allows them to grow in their professional career and build their own career paths. The point is that many of the opportunities that mobility can provide will only become visible after joining the corporate environment. An emerging trend

4 Employability Perspectives, Mobility and Skill Requirements

is that companies place more value on people who are or have been mobile so they can bring to the company good technical competences enriched with additional skills, competences and experiences acquired by working in other organisations and countries.

Whereas all this is true for all types of professions and careers, it is particularly important for doctorate holders, especially with regard to international experience. Geographical mobility is becoming an integral part of researchers' professional careers and reinforces the person's ability to deal with multicultural and multidisciplinary challenges. It is common for global companies to expect their employees to move around the world temporarily, and lack of (or unwillingness to gain) international experience may mark down the otherwise well-qualified candidate. Also, mobility experience can be indicative of the capacity of adaptation to different environments and cultures, which may be valuable when trying to move to another sector. Inter-sectoral moves are more risky for both the doctorate holder and the new employer, particularly if the applicant has never had direct experience in the sector before (e.g. moving from academia to for-profit business or policy making bodies). Previous good intra-sectoral experience (worked in more than one organisation within the sector) cannot guarantee the success of an inter-sectoral move, but it can certainly help.

DOC-CAREERS company interviewees indicated in general that businesses value mobility of doctorate holders, both within the company and with interaction with the academic world and that it enhances their employability. Previous experiences in other companies are very much appreciated and so is intersectoral mobility when reinforcing partnerships with universities and research centres. For most of the companies interviewed, the ability of doctorate holders to understand different areas of knowledge and work across them is seen as crucial, since innovation is borne mainly at the boundaries of disciplines. To delve more deeply into this issue, company interviewees were asked about mobility strategies for their researchers to develop their careers and serve the company better. The following discussion shows trends and strategies of mobility within industry and between industry and academia.

> *"The most important competence, besides core competencies all researchers should have, is 'experiences': they should have had opportunities to work in teams, with other universities, or in a company. They must be able to prove their capacity to work with the external world."*
>
> Lisbeth Jacobs, Bekaert

Mobility is important at all stages of doctorate holders' careers, and it is expected that this requirement will only increase as more companies become aware of the benefits it brings to them. However, there can be serious problems related to mobility within the public sector, relating to social security and pension rights. Large international companies will generally have schemes in place to address these problems.

4.3.1. Mobility within industry

Intra-sectoral mobility

Most of the interviews gave evidence that doctorate holders are initially recruited as researchers and over the years in a company, if they stay, they tend to move from research to other types of positions (vertical mobility) and/or from one discipline to another (horizontal mobility). In large R&D corporations, doctorate holders will probably find opportunities for promotion that take them away from research at different stages during their careers. Fig. 4.3.1-1 shows general trends on doctorate holders' vertical mobility: on average, 20% of those initially recruited as researchers had moved to managerial or sales positions after 5-10 years of career in the company. These moves over time depended very much on each company (quotes below) but the tendency was quite clear: project management and line management are the likely future responsibilities of many doctorate holders

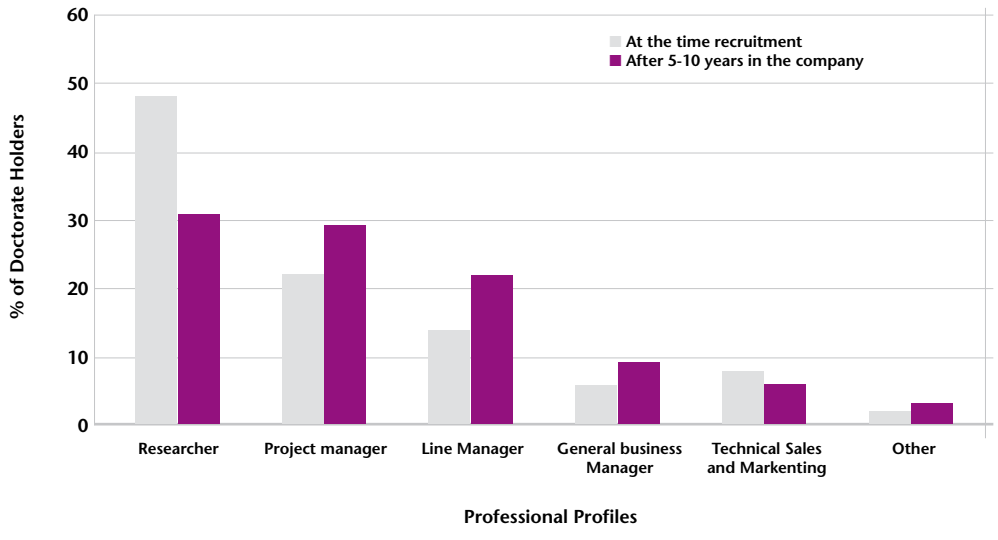
who were initially recruited as researchers. Similar trends apply to the career paths of Bachelors and Masters initially employed in R&D positions. It is not just the expertise that doctorate holders have acquired through their education and training that equips them for high-profile senior positions. Scientific and technical knowledge combines with broader business experience as a key factor of leadership in managing scientific teams.

Examples from the Case Studies: Mobility within industry

- *Arcelor-Mittal:* "Generally speaking, when hiring a doctorate candidate, he/she will work for 5 to 10 years in research. Eventually, only 20% will continue in research positions, the large majority will be moving to industrial and managerial careers."
- *VTT:* "In general, 80% of staff initially recruited for research positions will become project managers with both research and technical functions. Having a PhD degree is not essential for line managers, but it is important that in the past they have participated in technological projects in specific areas of expertise."
- *Synpo:* "The majority of doctorate holders are recruited for research and most of them will stay in research because it is our specific field of activities. Only some of the doctorate holders will become team managers."
- *Arjo Wiggings:* "A junior doctorate holder would be working in a research group under the supervision of a group leader, within a team of 4-5 technicians, engineers, etc. Subsequently, competent doctorate holders can become group leaders and, later, continue their career in general management and at the corporate level. The most ambitious will become 'project leaders'; others can become commercial representatives. Arjo Wiggings has a very open policy concerning mobility and tries to motivate competent people by proposing challenges to them in different fields and departments. However, E. Buhannic highlighted the fact that most researchers really like to do research and want to stay as researchers and the company does not want to force them to become managers."

Source: EUA DOC-CAREERS Project

Figure 4.3.1-1 Trends in doctorate careers paths in DOC-CAREERS interviewed companies



Source: EUA DOC-CAREERS Project

4 Employability Perspectives, Mobility and Skill Requirements

Career schemes and promotional styles

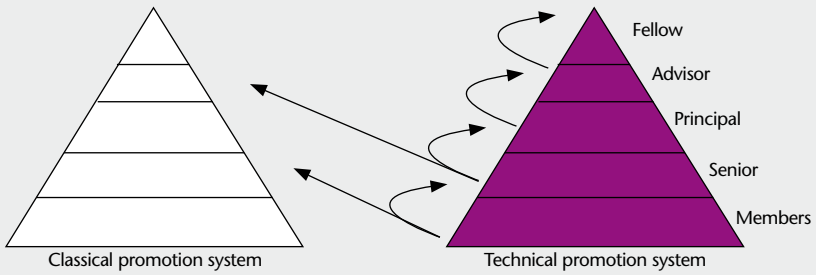
Some companies develop career paths and promotional schemes for doctorate holders with the aim of retaining the best and in positions where they can best perform. Large R&D corporations tend to allow people to choose their career path according to their competences and preferences. There is a traditional perception that managerial careers in companies are more valued than careers in research (although examination of the career pathways of many successful managing directors quickly dispels the notion that technical background is irrelevant). For this reason, companies develop schemes that value both research and managerial achievements. The reality is very diverse, as the following examples show:

- In *Nestlé* a doctorate holder can follow three career paths: researcher, project manager or line manager. Doctorate holders can take one of the three after an initial period to adjust to the company.
- *Thales* cares very much for what they call the 'engineer-researcher' profile, i.e. a person with a set of skills and competences of great value to the company. To retain them in the company is a major challenge and they try to do so by providing timely career opportunities. They have established a dual ladder to give proper recognition to technical progress in the company.
- *L'Oréal* evaluates researchers' careers on a yearly basis with no distinctive approach to doctorate holders.
- *Lafarge* ranks its scientists according to five criteria based on the quality of their research, publications, training and mobility: "*This motivates researchers' performance*".
- *Oridis Biomed* said they performed a yearly evaluation according to yearly goals in line with a career path.
- *Schlumberger* normally recruits a researcher based on his/her knowledge background, skills and competences. Later on, they allow the person to make a choice between a research and a managerial career. Both profiles are equally valued by Schlumberger (see Schlumberger detailed information).

Less pyramidal promotional schemes also exist, such as the one reported by Infineum: "*The company staff organisation chart is very flat. We focus on innovation and give professional growth opportunities within possibilities and reasonable expectations. Starting from a researcher position, a person can evolve within the company science community, move to a managerial position or move up within the organisation. We do not have a pyramidal structure. Those performing really well get promoted by giving them more responsibility or more complex projects. This can also create problems because the promotion may not be very visible, especially from the outside, but it works for us.*"

Valuing technical positions - Schlumberger

Schlumberger realised about ten years ago that some researchers had moved into in managerial positions because they wanted to make a career in-house while, actually, they would have performed better in research positions. To address this situation, Schlumberger developed a promotional ladder for people willing to pursue an in-house research career, in parallel to the classical one for managers. Evaluations for promotion and salary updates are organised in a similar way. To move up the scale, an employee would be evaluated by a commission composed of researchers, engineers and managers. Five criteria applied: technical competency; ability to find a solution to technical problems; impact of his/her work on the business; coaching/monitoring (internally and externally); internal and external visibility.



Source: Schlumberger

Some companies take mobility even further and encourage mobility between companies, mainly for researchers in the basic research department. For these companies it is absolutely essential that researchers keep an open mind and do not limit their research to strict company boundaries and cultures. This is a scheme that, for example, Thales welcomes as long as researchers work in a framework of fundamental research areas with low impact on intellectual property issues.

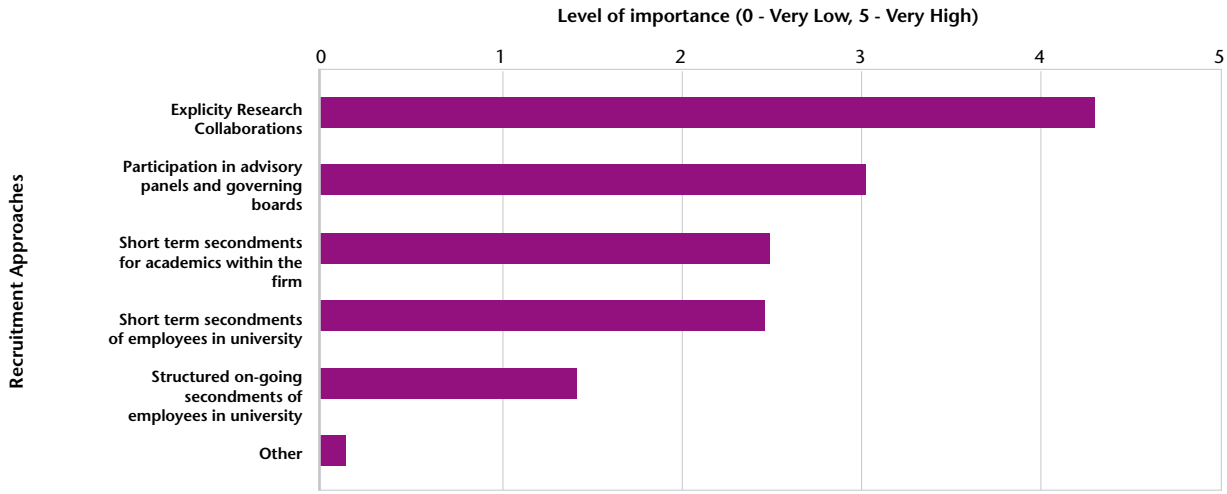
4.3.2. Mobility between Industry and Academia

Companies are increasingly becoming aware of the benefits of continuous collaboration with universities beyond their more or less continued contract research. Companies who establish long-term partnerships with universities foster continuous knowledge exchange between both organisations. Some companies, such as Philips have a long tradition of structured relations with universities and use many different methods.

Fig. 4.3.2-1 shows the importance that companies interviewed attributed to different practices of cooperation with universities on a scale of '0 - Very Low' to '5 - Very High' importance. The type of collaboration that was rated the highest is the traditional specific contract research, but participation in advisory panels (of industry employees and university researchers in each others' boards) and secondments, with their different modalities were also rated reasonably high. Apparently, large R&D-intensive companies increasingly encourage on-going temporary secondments of their employees in universities and vice versa.

4 Employability Perspectives, Mobility and Skill Requirements

Fig. 4.3.2-1 Practices of continued university-industry cooperation



Source: EUA DOC-CAREERS Project

Some of the companies stressed that they also welcome secondments of doctoral candidates, Bachelor and Master students. Students in internships are frequently considered potential employees. Secondments of academics in business or business employees in academia are valued by R&D-intensive companies. However both sectors agreed that this practice is not easy to implement and that there are structural and environmental factors (e.g. career benefits, peer group recognition) inhibiting the regular movement of employees between the academic and non-academic sectors.

The 'Other' type of collaborations revealed interesting initiatives in the very long term, where companies designated individual employees as 'ambassadors' in charge of relations with one university. For example:

- In Schlumberger, an employee can act as an ambassador of the company in one of the universities with which they collaborate. This person is in charge of forging and maintaining relations with the university (e.g. recruitment, research partnerships, donations, organisation special information days).

- Thales created a programme including visits, conferences, stages, etc. for students from higher education institutions where its employees were educated. The programme is managed by the universities' former students themselves, hence they close the circle and engage with the next generation.

4.4. Skill Requirements for Enhanced Employability of Doctorate Holders

What makes doctorate holders more employable? University-Industry dialogue on transferable skills

As reported before, some of the participant universities supplied data on employment destinations of their doctorate graduates which showed a great deal of diversity of employment, both in academic and non-academic sectors (Annex 7.4.). These data echo the diversity also reported by other data collections on professional destinations of doctorate holders (such us UK GRAD Programme, now Vitae

and OECD). DOC-CAREERS explored the views of employers on the skill requirements for enhanced career opportunities of doctorate holders. The project also explored initiatives of universities and intermediary bodies to raise awareness of and training on transferable skills to enhance the employability of doctorate holders, both in academic and non-academic sectors. Contributions reported in this section include:

i) the views from non-academic employers (interviews with the 31 R&D-intensive companies, and R&D-intensive SMEs working in cooperation with universities and research organisations such as VTT)

ii) the outcomes of workshop dialogues - Workshop I on "Transferable Skills" and Workshop III on "Towards enhanced employment opportunities" including university professors, doctoral candidates, R&D-intensive company CEOs and other stakeholders.

iii) some initiatives developed by universities and research institutions to train and raise awareness of transferable skills in doctoral programmes; initiatives by intermediary bodies assisting doctorate holders in finding employment (ABG, France and Consejería de Educación - Comunidad de Madrid, Spain).

Raising awareness of the transferable skills needed for enhanced employment opportunities is very important to help doctorate holders prepare themselves better for their future employment in the labour market, especially if they intend to work outside academia. In general, the skills that are most valued by non-academic environments include first of all their deep knowledge of an area of knowledge and the embedded skills that go along with research training. However, skills such as long-term planning, the "breadth and depth" of an area, interdisciplinarity, international experience and original thinking are amongst the most valued by doctorate holder employers. Based on these views, many universities nowadays include seminars and information days to address employability issues and their relation to transferable skills.

The following sections will illustrate through the DOC-CAREERS dialogues on transferable skills that employers look for professionals with "the breadth and depth", also called "T-shape individuals" and that universities which are used to work with industry are aware of the broad range of transferable skills needed in the labour market. Examples of universities and other intermediary bodies implementing initiatives to raise awareness of career opportunities and training on transferable skills will be also shown.

4.4.1. Companies' Views

The outcomes reported in this section include companies' views on skills required by doctorate holders in their first employment in industry (Fig. 4.4.1-1) and discussions focused on several related aspects: a) their remarks on skill requirements, b) general areas of strengths and weaknesses and general assessment on the performance of doctorate holders in the company, and c) the level of satisfaction of their doctorate holder employees in their companies. Outcomes and recommendations by industry are summarised in Fig. 4.4.1-2 and Table 4.4.1-1.

a) Skill Requirements

One of the objectives of the company interviews was to learn about the skills that R&D enterprises valued the most when hiring doctorate holders. DOC-CAREERS company interviewees were asked to rate the importance, at the moment of recruitment, of a number of skills related to science and management on a scale of '0 - Very Low' to '5 - Very High'.

Fig. 4.4.1-1 represents the average rating of all participant companies. It illustrates the high expectations they have for doctorate holders, as no skills were rated low. As mentioned before, doctoral education is about research and, realistically, companies can expect doctorate holders to have mastered skills and competences strongly related to research and to have a reasonable, but more limited, awareness and development of others. The industry experience of a doctorate holder may consist only of temporary placement during his/her studies. As A. Shat, Philips, said: *"We can provide*

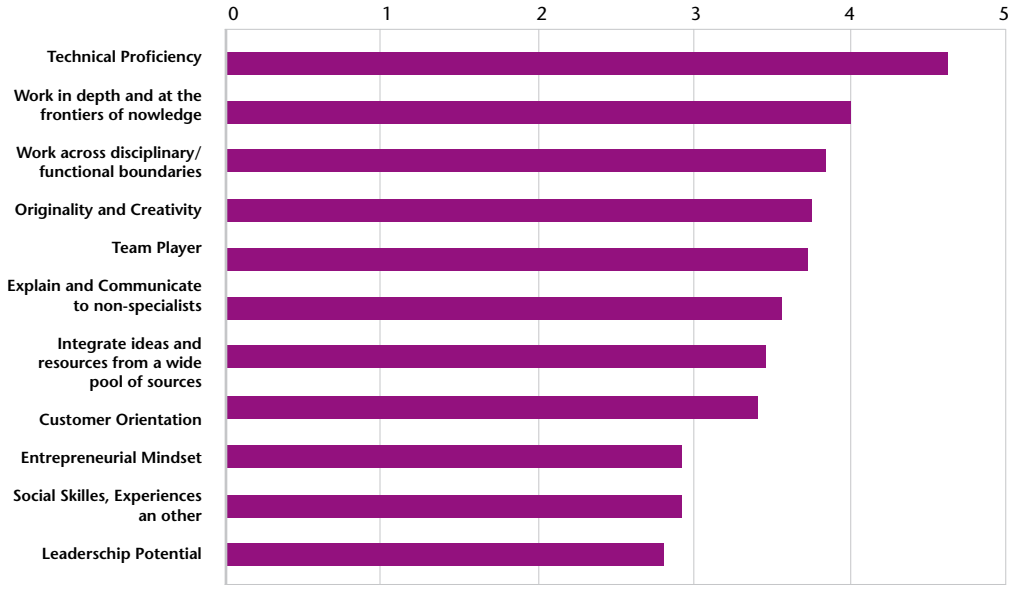
4 Employability Perspectives, Mobility and Skill Requirements

additional necessary training. What is important is the potential we see in the applicant."

The graph illustrates that specific skills related to science which were 'technical proficiency' and ability to 'work in depth at the frontiers of knowledge', were the most valued at the moment of recruitment. However, many considered that the ability of researchers to be team players, original and creative, and able to work across disciplinary boundaries were also important (between 3.5 and 4 in a scale of 0 to 5). The rest of the skills, broadly more related to management were also rated quite high (around 3 and 4 on a scale of 0 to 5). Among the main reasons why companies considered that many of these transferable skills were a 'must' were:

- Companies preferentially employ people with experience in industry, especially if it has been gained in the same industrial sector.
- They expect doctorate holders to play different roles as researchers and as managers, e.g. being able to start new research projects within or managing a team of people, to apply for funding or attract other companies to work in a research project.
- They expect the doctorate holder to be able to react quickly and effectively to unpredictable/ unforeseen situations, and be flexible when working with different environments and people.

Fig. 4.4.1-1 DOC-CAREERS company case studies: Average rating of the importance attributed to skills of doctorate holders at the time of recruitment



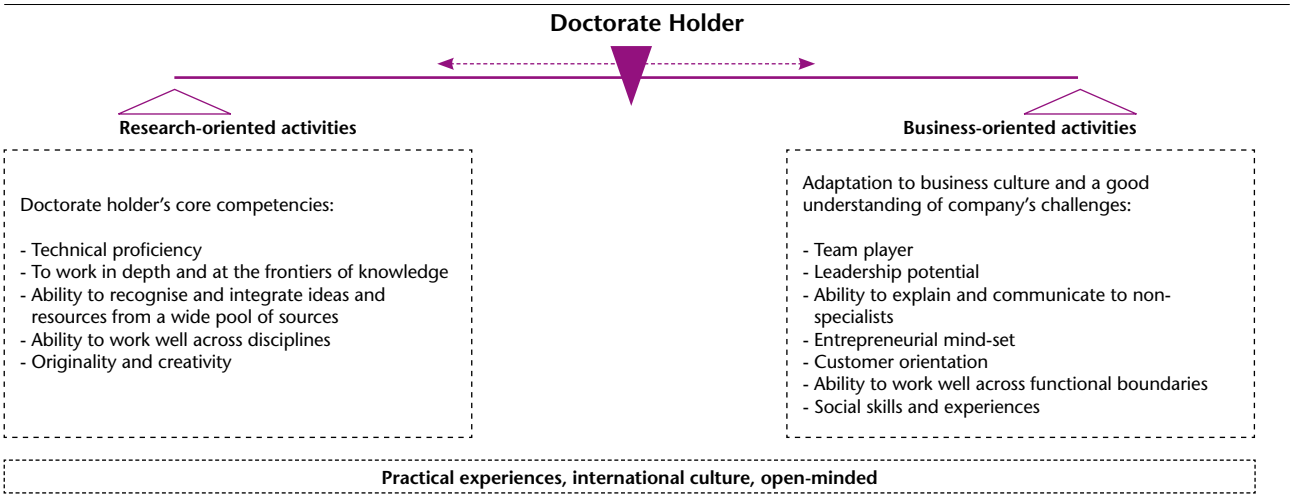
Source: EUA DOC-CAREERS Project

In summary, what is most important is that the doctorate holder brings experiences in addition to those gained during the doctoral process carried out in a university (Bekaert). This is a reason why companies employ doctorate holders with different backgrounds. Comments by the interviewees in the context of this question revealed very interesting trends in their preferences and needs for doctorate holders. Interdisciplinarity is key, since nowadays many breakthrough discoveries are made on the borderline between different research fields and companies tend to create environments that foster breaking down disciplinary borders. It is then when the capacity of researchers to communicate effectively with researchers from other disciplines is essential. Adaptation to the company culture can also be an important issue (e.g. Corus, Solvay, Inifineum). Part of the cultural ingredient is the situation that faces companies employing candidates with various national backgrounds. For example, Lee Sprung, Infineum, highlighted that in the US there are excellent US/Indian and US/Chinese scientists and engineers with strong native cultural ties and enormous difficulties in being team players and integrating with the company culture, even those educated in the US. Language can also be an issue for R&D companies located in non-English speaking countries who need doctorate holders are able to speak English fluently (e.g. Synpo).

> *Young doctorate holders should be aware of how important interdependency and interdisciplinarity is.*
>
> Jean-Yves Colombel, from Thales

To summarise the views in a graphical way, Fig. 4.4.1-2, represents the skills which are required to develop doctorate holder careers depending on how they are oriented towards research. Obviously, the reality is very diverse and the relative importance of skills varied from company to company and from position to position (see L'Oréal detailed information). At the extreme of the 'Doctorate Holder' line there are two archetypes of skill sets for very research-oriented activities or very business-oriented activities. Putting skills into boxes is evidently an oversimplification, but the dotted lines indicate this. Indeed, whether in academic positions or not, in lower or higher level positions, doctorate holders will normally need some of these skills at some point in their careers. Throughout their careers, doctorate holders can try and look for jobs which match their competencies as they evolve with time.

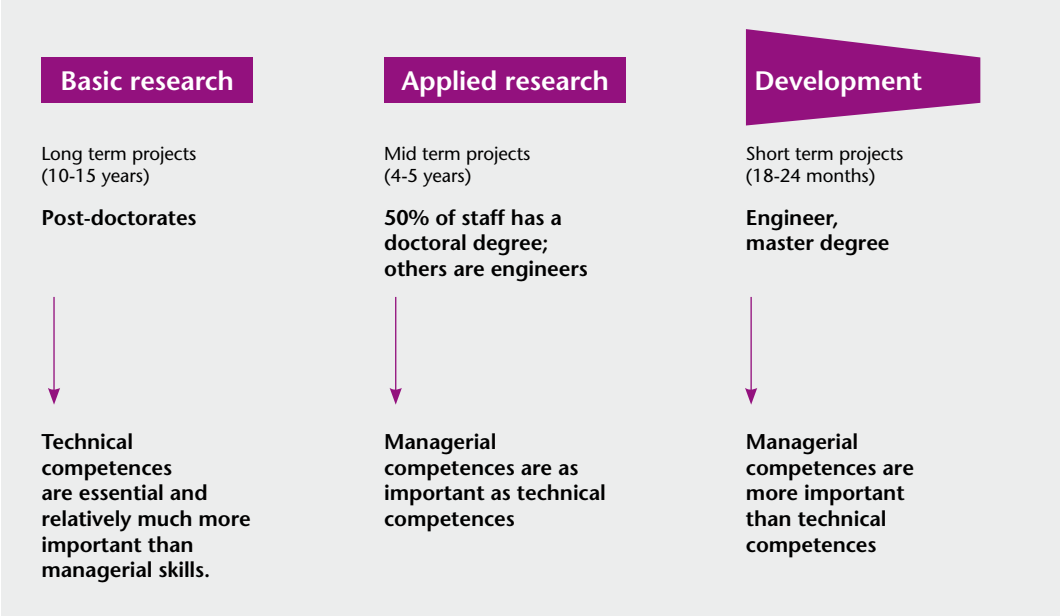
Fig. 4.4.1-2 Dynamic skill requirements of doctorate holders associated with different career options



Source: E. Chassagneux (EIRMA)

4 Employability Perspectives, Mobility and Skill Requirements

Skill requirements for different positions – L'Oréal



Source: L'Oréal

Companies in general thought that universities could do a better job in terms of helping students to develop transferable skills, such as team player, entrepreneurial mind-set or customer orientation. Some companies stressed that universities should concentrate on educating excellent scientists because they can provide the additional training needed (e.g. Schlumberger, Philips, Arcelor Mittal, Thales).

Examples from the Case Studies: Skill Requirements

- *Solvay:* "People should be aware of the value chain in industrial environments, understand that different segments need different perspectives, and understand the customer".
- *Arcelor Mittal:* "Universities should help the candidate to be more effective in the skills mentioned above. However, Arcelor Mittal proposes integration weeks for all new researchers and PhD candidates."
- *Lafarge:* "The most important ability for us is to be a team player. Most Lafarge R&D projects are pluri-disciplinary. The doctoral candidate might have a minimum ability to communicate with team members whose field of expertise is different from his own."
- *Thales:* "The academic experience is not enough. This is a reason why Thales created the Thales Chair and developed an Engineering University. We identified twelve 'exigences critiques' (necessary skills in addition to the technical ones) which can be grouped in three categories: a) communication, b) awareness of business environment, c) know-how on processes, available techniques and methodolgies."

Source: EUA DOC-CAREERS Project

b) General areas of strengths and weaknesses in first employment in industry

The unanimous opinion of company interviewees who employed doctorate holders was that they were very satisfied with them. They praised their good performance on scientific and technical research issues. Their responses expressed views such as: *'They conduct high level projects; high level of thinking'; 'It is generally good provided that they are self-leaders and good at communication'; 'We are very happy with those who have some working experience in companies'; 'The experience is very good because the PhD Programme includes a careful assessment of a PhD candidate before he/she is selected'; 'Very satisfied: we have access to the best'*.

On the technical side, the only negative remark was a general lack of awareness of intellectual property issues, market regulations and directives. But, of course, junior doctorate holders lack this broader experience because they have been trained for research and by researchers for 3-5 years. Table 4.4.1-1 reflects the general views of companies in relation to the skills of doctorate holders in their first employment in the business enterprise sector and their solutions and recommendations to circumvent the problems.

When asked about the areas of weaknesses at the moment of recruitment, interviewees' responses were of the type: *'Insufficient level in transferable skills'; 'Not sufficiently business-oriented'; 'Limited sense of budgets'; 'Lack of communication skills'; 'Difficult understanding of time and budget constraints'; Not sufficiently open minded',* etc. However, companies that had worked extensively with doctoral candidates tended to be less critical and some provide support to newcomers during their initial period in the company to help them to adjust. Companies in collaborative doctoral programmes, such as IBM, Philips, Haldor Topsoe and Renault clearly indicated that a key success factor was the thorough selection procedure of doctoral candidates in their programmes, and the formalisation of the collaboration by an agreement, after transparent discussion on the rights and duties of each part. Although nobody can ensure success, these practices minimise the risk of failure.

Companies suggested several recommendations to address the weaknesses from their side including: i) Clear definitions the skills and competences they need in doctorate holders; ii) Participation in collaborative doctoral programmes; iii) Organisation of accompanying measures for newcomers. For universities, they recommended to keep educating good doctorate holders with a sound scientific background but 'do better' in transferable skills training. There were several, some controversial, discussions on transferable skills during DOC-CAREERS project and the outcomes are reported ahead.

Table 4.4.1-1 Synopsis of enterprises' views on doctorate holders in their first employment in industry at the time of recruitment

General Areas of Strengths:

- Scientific and technical skills (opinion of 100% companies: Good, Very good or Excellent)

Weaknesses:

- Unawareness of IP and market regulations – too oriented towards publication
- Lack of business mindset (customer orientation, value chain, flexibility and sensitivity to market segments, budget and time constraints, sudden change of research priorities, etc.)
- Limited communication skills and team-work orientation

Industry Solutions and Recommendations:

- Definition of the profiles needed
- Participation in collaborative programmes, including
  - Thorough selection of doctoral candidates
  - Clear discussions on expectations, responsibilities and rights
  - Signature of an agreement
- Industry accompanying measures for newcomers (integration weeks, personalised support, etc.)
- Universities 'should do better' in transferable skills

Source: EUA DOC-CAREERS Project

4 Employability Perspectives, Mobility and Skill Requirements

c) How satisfied do companies think their doctorate holders are

Some of the participant companies responded to this question by using their low turn-over of R&D staff (many below 3% in stable conditions) as an indicator of the generally good level of satisfaction in their companies. Those working with doctoral candidates from collaborative doctoral programmes reported high percentages of doctoral candidates' recruitment after the completion of their doctoral project (from 40% up to 80%, depending on the year). As mentioned in previous sections, placements in industry are a unique way to test the mutual compatibility between a doctoral candidate and a company. Hence, accepting an employment in the host company is another sign of general satisfaction.

A common remark by companies was that the satisfaction depended on the extent to which the range of activities met the expectations of the doctorate holder. Those who were employed as scientists and did research were normally satisfied, provided that they adjusted to the different mindset (e.g. Stora Enso, Outokumpu) and that they accept the dynamics and pressure of deadlines (e.g. Arcelor Mittal). Companies which offer career development programmes and/or multiple careers options for doctorate holders (R&D, executive positions, technical Sales, etc.) also reported a very low turn-over of their doctorate holders.

Examples from the Case Studies: Satisfaction of doctorate holders

- *Stora Enso:* "It depends on the expectations of the individual. If a person thinks that research in a company is the same kind of research as in a university they will not be happy in the long term, they will be constantly missing the university-type of research."
- *Outokumpu:* "For some, industry research may be a little bit frustrating because is not so free as in university."
- *Renault:* "They are very satisfied, specially because doctoral candidates are considered as Renault employees during their thesis period. If they eventually become employees after their doctoral project, they will already have had three years of in-house experience, which counts for salary purposes."

Source: EUA DOC-CAREERS Project

d) Notes on other employers: SMEs and research organisations

It is relevant to report here a few remarks on these also important employers of doctorate holders although they were not studied in so much detail as the large R&D-intensive corporations. SMEs have a very significant role in developing the local economy. DOC-CAREERS case studies which reported cooperation with SMEs at doctorate level indicated their needs for a broader range (and high level) of transferable skills – specially interpersonal skills – at the moment of recruitment. A main reason is that labour division is less fragmented than in large companies and the doctorate may be assuming management tasks right from the start. Hence, skills related to business environment awareness, for example, should be already embedded in the doctorate holder mindset to be able to perform adequately. In large R&D-intensive companies management tasks may be assumed at later stages, and the doctorate holder can have the opportunity to develop the necessary skills during his/her first years in the company. If SMEs become larger employers of doctorate holders for positions in which they could fully develop their capacities, SMEs would be a strong vehicle to encourage doctorates into local and regional economies.

Research organisations are also large employers of doctorate holders and they need researchers with a good level of transferable skills. For example, the Helmholtz Association recently developed

an initiative to raise awareness of transferable skills and career opportunities in life sciences[43]. Another important employer of researchers, VTT Technical Research Centre of Finland[44], has clear views on what are the transferable skills that they need at Master and Doctorate levels (see VTT detailed information) and offers training for doctorates on management and leadership, advanced project management, advanced intercultural, commercial skills, etc.

VTT: a research organisation employing researchers

From the VTT point of view, the following transferable skills are important at the doctorate level:

- Communication skills
  - process of writing scientific articles as well as being able to write fluently
  - presenting own papers in conferences
  - addressing different audiences about one´s own discipline
- Acquire and synthesize knowledge
  - ability to effectively use electrical tools in finding useful knowledge
  - ability to critically evaluate different theories and knowledge
  - ability to see the "big picture" of one´s own discipline – and possibly some related disciplines
- Commercial awareness
  - ability to formulate the thesis research problem so that it also tries to bring new knowledge from the customer or end-user perspective
  - interest to broaden one´s network to people working at the private sector
- Interaction with other disciplines
  - interest to network with representatives of other disciplines and to look for new innovative solution
  - building broad networks with other scientists and stakeholders
- Research management
  - knows the life cycle of a research project starting from an idea or a concept
  - knows different instruments of research funding and can apply for funding

Skills expected at master level: good general communication, team working, problem solving, project management and intercultural skills.

Personal PhD career and recruiting criteria:
In the Scandinavian countries many PhD students begin their studies after they already have some work experience after the Masters´ degree. Many of them already have some work experience before getting the Masters degree. They may also be full or part-time employed by another organisation while working on their thesis. When Finnish organisations recruit PhD holders, they look at the person´s career as a whole. When recruiting a PhD holder, VTT emphasizes the applicant´s area of expertise. This should be close to our strategic technological core competencies. We also look at the applicant´s previous work experience and network both to the academia and to the private sector. PhD holders are expected to be active in starting new research projects, applying for funding and trying to get companies to participate in the research projects. They also are expected to act as project managers.

"In general, VTT is quite pleased with its PhDs. Their tasks are very technology-oriented. Generally speaking, PhD candidates do not need to be more qualified. However, doctorate holders do not have a sufficiently tangible experience in industry."

Marja Lindgren, VTT

Source: VTT

[43] http://www.remat-project.eu/cms/
[44] VTT Technical Research Centre of Finland, http://www.vtt.fi/, is an impartial expert organisation. Its objective is to develop new technologies, create new innovations and value added thus increasing customer's competitiveness. With its know-how VTT produces research, development, testing and information services to public sector and companies as well as international organisations.

4 Employability Perspectives, Mobility and Skill Requirements

4.4.2. Universities' Views and Dialogue with Industry

The DOC-CAREERS dialogues which included universities with regular relations with industry showed that universities are well aware of the broader needs on transferable skills in academic and non-academic environments. The skills on Table 4.4.2-1 were listed mainly by experts from universities in three independent working groups corresponding to the three areas of knowledge addressed in DOC-CAREERS, namely SET, BML, ESS, during Workshop I[45]. As it can be seen, there is a general consensus on the core transferable competences that a doctorate holder should have, and these are quite independent of the field of knowledge. Main core competences include social and communication skills, management, creative thinking, capacity of dealing with complex and multidisciplinary work and team work.

It was generally accepted that these lists of broad competences complement each other and that researchers still need training on them but at different levels and for different contexts and they are necessary for certain jobs (e.g. research management). The lists are neither exhaustive nor applicable to all possible jobs for a doctorate holder but show that it is in alignment with the skills valued by companies (Fig. 4.4.1-1) and other research organisations, such as VTT. Universities have to prepare graduates for the broader labour markets, nowadays in constant evolution, and, as Arjen Shat from Philips said in Workshop I, *"…the required skills cannot be predicted beyond a certain detail because job profiles can be very specific. If a suitable applicant to a job position did not have an acceptable level of certain skills but the company sees s/he has the capacity to acquire them, they could provide necessary means to develop them."*

Table 4.4.2-1 Transferable skills for doctorate holders listed by universities (Workshop I)

Science, Engineering and Technology (SET) & Biomedicine, Medical, Life Sciences (BML)	Economic and Social Sciences (ESS)
• communication . Evidence-based influencing people . Oral skills for broad frameworks of audiences (interdisciplinary teams, expert conferences, science for society, workshops) . Ability to communicate with people with different levels of education • acquiring and processing information • synthesising knowledge • integrating knowledge from different disciplines • leadership: team management, dealing with uncertainty, conflict handling • failure management • commercial awareness (market, IPR) • research Management • creative thinking (discovery, imagining solutions) • negotiation • understanding of business environment • user requirement consciousness • coping with conflicting demands	• analytical skills • methodological knowledge and skills • communication and presentation skills • management skills • international, intercultural experience and competence working in such environment • language skills • people and relationship management skills • computer science skills • hard science knowledge (to a certain degree), e.g. statistics • interdisciplinary skills and knowledge – broader picture and understanding of the world • entrepreneurship • socials skills in different context (in different socio-economic environments) • creative thinking, innovation (thinking out of box) – new ideas beyond disciplines • ethics • problem solving • fundraising

Source: EUA DOC-CAREERS Project

[45]. http://www.eua.be/fileadmin/user_upload/files/EUA1_documents/1st_WS_DOC-Careers_OUTCOMES_new.pdf

Often, the dialogue on transferable skills for doctoral candidates goes together with the need to raise their awareness of the broader spectrum of employment opportunities beyond academic environments and the role that their network of contacts built during the doctoral process can play in helping them finding their way through the labour market. Universities and supervisors should be aware that these trends are going to consolidate in the next years, so they should take steps to raise awareness among the doctoral candidates and thereby reduce mismatches of perceptions and expectations after graduation. The role of contact networks should be emphasised as a soft tool to preserve contacts after the doctoral period and to help doctorate candidates/holders to create their own culture to manage academic and non-academic relations. It should be left up to the doctoral candidate to forge his/her own career path.

Universities reported that training on transferable skills during the doctoral period can be a matter of controversy within the academic community. Transferable skills are needed at all levels in education and there are still unclear boundaries to which extent they should be addressed at doctoral level and not before. Some supervisors are resistant to let the doctoral candidates attend seminars and optional courses devoted to transferable skills because they consider it is a time lost for research. Doctoral candidates also showed concern about putting excessive emphasis on transferable skills in detriment of the research skills and supported the suggestion to keep their training on a voluntary basis.

The DOC-CAREERS university-industry dialogue on training on transferable skills in doctoral education was sometimes controversial. Besides the general agreement that transferable skills for doctorate holders are definitely necessary, both in academic and non-academic environments, there were different views on the convenience of including their training as a structural component of the doctoral process. For large companies, the value of recruiting a doctoral holder usually lies in his/her deep knowledge of a relevant subject, understanding of the methods of research and a capacity to solve problems. They insisted that "teaching" transferable skills in the university is not essential since they can provide this training when necessary. This was also the opinion of some representatives of High Tech SMEs. However, as it has been indicated before, most of SME representatives (and also professors collaborating in research involving SMEs) placed high value on doctorate holders who have soft skills that complement their research capabilities at the moment of being recruited. It was agreed that, in any case, pre-existing transferable skills in a doctoral candidate should be recognised and avoid unnecessary training that would take time away from doctoral research.

Apart from the degree of structure in training on transferable skills, it is important to make the implicit acquisition of skills that takes place in doctoral programmes more explicit to doctoral candidates, employers and supervisors less familiar with labour markets outside academia. In fact, making the doctoral candidate aware of the skills s/he is acquiring naturally during the normal conduct of the doctoral research is already an improvement. Many doctoral candidates work in a research group, laboratory or department where they can develop and refine skills such as team work, negotiations, conflict management and dealing with material and equipment suppliers. Those doctoral candidates who hold teaching assistantships or grants including teaching duties also develop communication and organisational skills. Those who go abroad incorporate international experiences in their background. Those who participate in collaborative doctoral programmes already embed transferable skills related to the business world in their mindset.

Doctoral candidates need to be aware of their own skills and competences and be able to convey them to potential employers in particular but also to the society in general. The skills of creative workers acquired during research training (e.g., capacity to deal with complex problems, work well in international environments, and think "out of the box"), can serve the knowledge society by developing new ways to deal with problems or finding imaginative solutions.

4 Employability Perspectives, Mobility and Skill Requirements

Examples

Some universities (e.g. Newcastle, UPMC, Ruhr-University Bochum, Imperial College, Mykolas Romeris) have established sound practices and report successful outcomes of their activities and efforts in raising awareness of, and providing training on transferable skills and career opportunities guidance46. Within their own styles and contexts, they can have a compulsory part to ensure a minimum level for everybody from where they can take additional training on a voluntary basis, as the following examples show:

Research School, Ruhr-University Bochum, Germany

The Ruhr-University Research School was selected for funding within the 2006 competitive call of the Excellence Initiative by German Federal and State Governments to set up overarching graduate schools. The close proximity of Life Sciences, Natural Sciences, Humanities, Social Sciences and Engineering on one single campus offer a particular chance to bridge the gap between research cultures.

Approach: *The current challenges in doctoral education, including the employability of doctoral candidates in the wider labour market, are addressed with a rather holistic approach within the Research School: inter- and transdisciplinary perspectives, the development of transferable skills and competences form an integral part both of the individual research training and the common Research School activities. This includes individual budgeting responsibility, organisation of scientific events, doctoral representation in decision making bodies of the Research School as well as participation in the Science College and a number of high-end transferable skills courses as outlined in the curriculum below.*

Curriculum*: Within their individual projects, doctoral candidates have the opportunity to carry out cutting-edge research in an internationally competitive environment, in close contact to and guided by their supervisors, and largely in teams together with other doctoral candidates. Curricular components (CP), which are designed to complement the research work, comprise 12 CP and can be classified in three general areas: i) Research-related training (8 CP), intended to provide in-depth disciplinary and interdisciplinary competence beyond the individual research project; ii) Training in generic skills (3 CP), for example, writing research reports, preparing manuscripts to be submitted to peer-reviewed international research journals, designing posters and oral contributions with or without visual support for presentation in front of international experts, raising the necessary support for the research projects (grants, proposals); iii) Science College: Cultivation of transdisciplinary perspectives (1 CP). This is an opportunity for the curious minds to get in contact with the diversity of science and science and society issues. It encompasses an annual Summer Academy and regular Science College Lectures.*

Courses can be selected from a large portfolio by each candidate in agreement with his or her supervisors to fit their individual training needs. Participation in the curricular requirements and progress is documented in an Individual Training and Supervision Plan. To foster mobility, there are funds for doctoral candidates to participate in international conferences or carry out research at partners institutions.

Mykolas Romeris University, Lithuania

At Mykolas Romeris University, Lithuania, in the field of social sciences transferable skills identified as valuable for employers, are divided into 5 main groups:

. Communication skills: Negotiations, Moderation, Argument presenting, Presentation, Interview conducting
. Inter-personal skills: Conflict resolution, Networking, Tolerance, Consensus reaching
. Decision-making, problem solving: Problems identification, analysis of situation, Creative thinking, alternative solutions, entrepreneurship
. Leadership: Objectives formulation, Changes management, Time planning, Coordination, Delegation, Feedback collection, Motivation building
. Employment search: Career planning, Salary negotiations, CV writing, Interview

Mykolas Romeris started several projects in cooperation with industry in the framework of a large agreement signed with the Confederation of Industry Companies and Association of Trade and Business Companies. Activities are structured in a number of projects addressing entrepreneurship, intersectoral mobility, development of activities with industry and training on transferable skills to prepare doctorates specially for the public sector. Several of these projects are funded by the European Social Fund.

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46. Webpages

Summary of Key Points

- More and better prepared doctorate holders for employment in both academic and non-academic environments provide better perspectives for Europe to become more competitive at a global scale.
- Transferable skills in doctorate holders are important for developing their careers both inside and outside academia. Raising awareness of skills acquired through the doctoral process is needed for doctoral candidates to widen their range of employment opportunities and mobility horizons.
- Transferable skills are learnt through experience ("learning by doing"), they cannot be mastered by only taking courses, and an appropriate level of their development has to be ensured at all degrees of education.
- Though very variable, the need for transferable skills training are differently viewed by R&D intensive companies (large or small) than by medium or lower R&D companies and by doctoral candidates/holders.
- There is a group of core competencies common to all fields that make a doctorate holder employable outside an academic context. They are related to communication, negotiation and management skills, long-term planning, and to the ability to apply creative thinking, the capacity to adapt to business contexts and deal with complex and multidisciplinary work.
- The attractiveness of the research career in Europe needs an enhanced science-society dialogue to create greater understanding of the potential benefits of the research, while recognising and weighing-up risks.
- Doctoral programmes should:
  - offer (not impose) a positive environment to develop transferable skills for both academic and non-academic careers
  - raise awareness of embedded transferable skills to be acquired during doctoral period without over-regulating, over-monitoring and over-charging the programmes
  - provide a common core of processes and outcomes but respect diversity and provide individualised training to help doctoral candidates to develop best their capabilities.
- Dialogue between academia and other employers should be strengthened. Doctoral candidates, doctorate holders and employers should have a higher degree of awareness of the transferable skills that are acquired during the doctoral process. Non-academic employers should, in general, become more aware of the transferable skills that doctoral graduates can develop.
- In addition to the progress in dialogue, further work is needed to develop models for transferable skills and at which level they should be addressed in doctoral education.

Other organisations assisting doctorate candidates/holders in their career development

There are organisations which act as an interface between the doctorate holder and the labour market (e.g. ABG, Vitae, Consejería de Educación-Comunidad de Madrid). They specialise in promoting the doctorate profile as a highly skilled professional, employable in many sectors of the economy. They provide information on employment opportunities both nationally and internationally, on the framework skill sets most likely to be required and provide support to raise the professional profile and enhance career perspectives. A valuable contribution of these interface organisations is that they contribute to raise the profile of the doctorate holder in the national and regional context because of close interaction with nearby employers. In this sense they reflect heavily local/regional values and culture. These organisations themselves employ doctorate holders aware of the related employability issues discussed in this section and report generally successful outcomes for their activities and efforts, as for example, ABG below.

4 Employability Perspectives, Mobility and Skill Requirements

Examples

***Association Bernard Gregory (ABG)**, France is a non-profit organisation which promotes training through research and fosters the integration of doctorate holders into the corporate world. It is composed of higher education institutions, research organizations and companies, funded by the French government and other public and private partners. ABG's activities to bring together the academic world and the world of business include: i) information and individual support programmes for doctoral candidates and doctorate graduates looking for jobs; ii) promoting training through research within the business world; iii) matching competences and skills of doctorate holders and company job offers.*

These activities are complementary to actions developed by doctoral schools, research and higher education "poles", and associations of PhD students. In addition to information on the job market for doctoral candidates (e.g. through their website, quarterly newsletter 'Docteurs&Co', forums, guidelines, on-line databases, access to national and international networks) they develop two main training initiatives:

- *the "Doctoriales": created in 1997, a residential one-week workshop to raise doctorate candidates' awareness of career development options, planning and of business environments.*
- *the "Adding value to skills" is an optional chapter in the doctoral thesis, where they have to show their own self-awareness of transferable skills in the context of their research.*

ABG reported that a majority of doctorate holders try to find employment in public research and higher education organisations. For those who look for a job in companies, the integration into the job market is fast with 70% finding a job within 6 months after the defence (of which 56% in private R&D sector). According to ABG, doctorate holders have an unleashed potential in terms of skills and competences which are valuable for employers.

5 Tracking of Doctorate Holder Careers by Universities

by Janet Metcalfe[47], Vitae, UK

As a separate but integral part of the DOC-CAREERS project, Janet Metcalfe (Vitae, UK) was invited to convene a small Working Group to consider the extent to which the tracking of doctorate holders' careers was practised at the university level and the methodologies used and results achieved. The group's work revealed that tracking was not widespread yet but that some good practices were in place that needed to be disseminated. There follows below a summary of the findings of the working group focussing on the main features of existing surveys, the challenges in developing them and the benefits to be gained from their implementation.

Introduction

The aim of the DOC-CAREERS in tracking doctorate holders' careers was to identify methodologies for data collection at institutional level, with the potential for wider application and transferability to other environments. It analysed, specifically: i) types of data tracking systems in universities, resources needed and challenges associated with setting up the data collection; ii) uses, benefits and outcomes of data tracking by universities; iii) applicability of the methodologies studied to other university institutions.

The calls for expressions of interest reinforced the conclusion from the Doctoral Programmes Project[1] that there are few examples of institutional mechanisms for tracking doctorate graduates' careers. Through the two web calls to the EUA membership for expressions of interest and wider requests through the networks of the Working Group, eleven institutions completed the tracking questionnaire (Section 2.2.).

One response described the UK national data collection undertaken by HESA (the data is collected by individual institutions and collated nationally). An additional response described the OECD Careers of Doctorate Holders (CDH www.oecd.org/sti/cdh) study, which plans to create comparable national datasets. Two of the responses came from one institution (Ghent University), which has developed an overarching database and suite of interlinking survey tools. Of the consequential nine relevant institutional responses, five came from within the Working Group.

However, the small sample does not necessarily imply a lack of institutional interest in data collection methods. Institutions in the process of developing instruments for tracking doctorate graduates' careers expressed interest in the outcomes of the project. There appears to be an understanding of the importance of data collection and evidence that this is an emerging area of activity: of the nine responses, five were newly established surveys. It is interesting to note that five of the responses were government/nationally funded. The Working Group believed that this project is timely and, hopefully, will be useful to institutions working in this area.

Within the sample, there was considerable diversity in the profile of the target cohort for the surveys and in the methods used. The Working Group believes that these examples offer institutions the opportunity to reflect on different approaches and appropriate mechanisms.

The target cohorts of doctorate holders in data collection and tracking surveys examples cover a range of target audiences, from countrywide surveys (UK, Finland and Belgium – Flanders only), those involving multiple institutions (UK, Finland and the Netherlands) and single institutional studies (Germany, Italy, Spain and Belgium).

Predominately, the surveys include all doctorate graduates from the institution/s. Exceptions are the London School of Economics (LSE) and European Molecular Biology Organization (EMBO) projects. The LSE study is a restricted study of doctorate alumni over an eight-year period, from a range of social science departments from four UK institutions, who are employed in academia in the UK or USA. The EMBO study traces two cohorts of EMBO postdoctorate fellows (1993 and 1998).

[47] Janet Metcalfe is Chair and Head of Vitae, UK, http://www.vitae.ac.uk

5 Tracking of Doctorate Holder Careers by Universities

There was similar diversity in the range of methods used for the studies, from one-off studies (LSE), through annual surveys (HESA), to tracking studies over more than twenty years (EUI). A significant number of studies were pilots to assess the suitability to embed within normal processes (Barcelona) or to extend nationally (Ghent, Utrecht).

The range of survey points extended from exit interviews (Leuven, Ghent, and Utrecht) through to extended periods after graduation. EUI regularly conduct a survey ten years after graduation. EMBO have recently done a comparative study of two cohorts eight and thirteen years following an EMBO postdoctoral fellowship.

Focus of the Data Collection and Tracking Surveys

The motivations for the studies cover a wide range of topics within two principle areas. These are providing input for the design and review of the structure and content of doctoral programmes and to obtain data on the career paths of doctorate graduates to inform doctoral candidates of career opportunities.

Other rationales for studies included:

- Reviewing the effectiveness of selection processes (EMBO)
- Understanding international and intersectoral mobility (Helsinki, Ghent)
- Understanding of how to prepare researchers for academic practice, particularly how important teaching experience is (LSE)
- Creating individual career profiles on job search and career progressions (LSE)
- Facilitate constructive departure from the institution and explore individuals' perceptions of institution policy and practice (Leuven)
- Understanding the skills and knowledge expected by employers (Jyväskylä)
- Reviewing the appropriateness of institutional doctoral programmes for labour markets (Barcelona).

Although the diversity of motivations, mechanisms and target audiences of the surveys prevent direct comparison, analysis of the types of data collected produced some interesting themes.

Those surveys interested in exploring respondents' experiences of doctoral programmes were most likely to ask about:

- the experience of doctoral programme
- the appropriateness of the doctoral degree for current employment/career
- the appropriateness of doctoral training for current employment/career
- the skills and competencies developed through the doctorate.

They were least likely to ask about:

- employment history prior to doctoral studies
- intersectoral/international mobility during doctoral studies
- reasons for non-completion of the doctorate.

Those surveys interested in understanding careers of doctorate graduates and the labour market were most likely to ask about:

- current employment
- satisfaction with career/current employment
- sector of current employment.

They were least likely to ask about:

- other work experience
- achievements since the doctorate
- intersectoral mobility since the doctorate
- future career intentions
- job security.

Methodologies for Data Collection and Tracking Surveys

Unsurprisingly, the most common survey methods are web-based and email questionnaires, supported by email communication. However, several studies also supplement these with paper-based surveys (Utrecht, EMBO). The Universities

of Helsinki and Jyväskylä studies both currently use paper-based questionnaires as their main survey method.

Unique amongst the example studies, the University Autonoma of Barcelona uses structured telephone interviews as its main survey method. These are conducted one year following graduation using current doctoral candidates who are trained as interviewers.

Following their pilot web-based survey, the LSE study will have an addition stage of conducting follow-up open-ended face to face interviews with a sample of respondents.

The study by the University of Helsinki includes an additional stage of structured telephone interviews with the employers of respondents.

Challenges

Institutions were asked about the challenges they faced in developing career-tracking studies. Probably the greatest challenge in tracking doctorate graduate careers is locating former graduates. All the long-term studies highlight the difficulty of contacting their graduates. A key measure of success depends on the institution having a robust database of alumni. EUI and LSE both have comprehensive alumni databases and use these successfully for their surveys. EUI achieve a 60% response rate for their ten-year studies. Part of this success is due to the expectation by the EUI of academic staff maintaining contact with their former doctorate candidates. Individually EUI departments undertake similar studies of their cohorts for the first five years after graduation. Other studies mention using Google, searching publication databases and contacting former supervisors to build as comprehensive a database of contacts as possible.

The short-term studies predominately use institutional databases. The studies based on exit interviews normally have automatic processes triggered by departure from the institution. Interestingly, these studies are the only examples that also include responses from doctorate candidates who did not complete their studies. Utrecht contact doctorate candidates through the official contact route for defence of the thesis.

Strategic challenges included agreeing the objectives for the study and gaining institutional commitment, both by senior management and academics.

Many of the operational challenges raised are consistent with any research project. Finding appropriate resources was highlighted as an issue by many: particularly finding staff with time and relevant experience of survey tools and securing IT support. Interestingly, those studies that had not obtained significant funding rarely raised funding as a major issue. The studies were seen as important projects and allocated small amounts of internal funding and resources within normal budgets and workloads. These studies all tend to use flexible survey tools that are relatively easy to set up and use. It is notable, however, that most of these studies, particularly pilot projects, acknowledged having insufficient time and resources for comprehensive analysis of the results.

Other challenges around data analysis included the difficulties of comparability with other institutions, aggregating or benchmarking results. LSE use a survey tool (BOS www.survey.bris.ac.uk) developed by the University of Bristol, which can be set up to allow participating institutions to compare their results against the aggregate results, without disclosing their own results to other institutions.

Data protection processes and meeting ethical codes were raised as important issues, particularly with multi-institutional studies. Strategic decisions included whether each institution needed to obtain ethical permission from their own institution or whether it was sufficient for the lead organisation to obtain permission for the project. One of the suggestions for reducing data protection issues was to ask permission at registration to contact the doctoral candidate after graduation.

Deciding on the methodological approach, survey and analytical techniques were not mentioned as challenges by any of the projects. EUI and Utrecht both based their surveys on

5 Tracking of Doctorate Holder Careers by Universities

existing surveys that have been well tested in the US. Several projects raised the difficulty of deciding which questions to include and keeping the questionnaire to an appropriate length to encourage completion. Unless there is a clear understanding of the aims of the project, it is too easy during the questionnaire design to lose focus and include interesting, but less relevant questions.

As mentioned earlier, by far the greatest challenges, raised by all projects that surveyed some time after graduation, are locating alumni and achieving appropriate and representative response rates.

Institutions that maintain alumni databases achieved significantly better reach and response rates. This is improved further when academic staff are involved and committed to the project. The EUI project is a good example of how departments have responsibility for maintaining information on alumni on an ongoing basis. Alumni are most likely to respond when there is an 'emotional attachment' to the institution: this is usually through the department.

One of the inevitable consequences of using departments to maintain records and search mechanisms, such as Google or publications databases, is a bias towards respondents from within higher education. There was also a concern that responses would also be biased towards the 'successful': alumni who felt they had not achieved their career aims would be less likely to respond to a survey.

Discussions during the third DOC-CAREERS workshop identified suggestions for how this bias could be minimised. It was felt important to create a continued 'emotional attachment' with the institution, irrespective of the career path of individual alumni. Examples included having an active Wiki-driven alumni network, actively run by past alumni. There should be an alumni 'promoter' who provides information on the resources and services of the alumni network and provides regular updates for members. The growth of doctoral and research schools should provide more routes to maintain contact with alumni.

Finally, although many of the example projects are still at the pilot stage, many raised the challenge of implementation of the findings and recommendations. They recognised the importance of providing feedback to respondents: particularly to ensure continued participation in future surveys.

Benefits

All the institutions that submitted examples of surveys recognised the importance of understanding the career paths of doctoral graduates. They cited the usefulness in informing the development and review of the structure and content of doctoral training programmes. Exploring the skills and competencies required by employers provides insight into the types of specific development activities that could be incorporated into the doctoral programme to enhance their employability in all labour market sectors.

A clear advantage of collecting career data is the opportunity for institutions to inform doctoral candidates, and their supervisors, of the career opportunities available for doctorate researchers. It also serves to demonstrate to potential doctoral candidates the potential employment opportunities and act as a marketing aid in the recruitment of the best researchers.

Several institutions highlighted an additional value of contacting alumni through the surveys, relating to the opportunity to build a pool of career profiles that illustrate individual career paths. Alumni are also invited to attend career events for current doctorate researchers to share their experiences of job search activities and employment. By engaging alumni through activities such as these, it reinforces the 'emotional attachment' to the institution.

Additional benefits emerge if institutions are able to compare their data with results from other institutions. This enables the institution to benchmark their doctoral programmes in terms of how well they prepare doctoral candidates for employment compared to other institutions.

Tracking Study Conclusions and Recommendations

Institutions generally recognise the usefulness of having robust and current data on the career paths of doctorate graduates. The examples in this work package demonstrate various methods by which a selection of individual institutions have set up mechanisms to collect this information either as a one-off study or on a more systematic basis. Only half of the examples here had external funding: the rest committed (often very small amounts of) internal resources and funding to drive this process forward.

However, all institutions need to recognise they have a responsibility to inform doctoral candidates of their likely employment options and to ensure that their doctoral programmes support the development of their employability.

The Working Group recommends that all institutions should track their doctorate graduates. Technological developments, such as internationally accessible web-based surveys and the availability of free/open source survey tools mean that the resources required to develop and implement a survey are considerably reduced compared with traditional paper, or even e-mail, based surveys. The web has also increased the potential of locating and building relationships with alumni.

This project has demonstrated that although few institutions are currently doing so, there are already examples of practice and experiences that other institutions can benefit from. All of the examples appear to be transferable to other institutional environments. To avoid reinventing wheels, the Working Group recommends that the EUA explores opportunities to encourage institutions to share practice further, possibly through the recently formed EUA Council for Doctoral Education, and further recommends that the survey tool designed for this project be developed into an open access web-based database of examples of practice relating to career tracking.

By sharing experiences, including rationales, methodologies, challenges and benefits, this may help create an environment where institutions are motivated to develop comparable datasets wherever possible for benchmarking.

6 Conclusions and Recommendations

Doctoral studies are among the most advanced and specialised forms of education and training available in modern societies. Their purpose can be defined in terms of providing society with the capacity for carrying out high quality research, and in terms of providing highly-qualified graduates with the skills and options to engage in their chosen careers. In both respects, social and individual requirements are changing. Today's attention to collaborative doctoral education is one manifestation of these changes.

A main objective of the DOC-CAREERS project has been to build constructive dialogue with and among stakeholders engaged in collaborative doctoral education. By these means, the project aimed to expand the available knowledge of the range of issues involved, the nature and extent of collaborative doctoral programmes, employability perspectives and their relation to so-called transferable skills, and the role of institutional tracking of doctorate holder careers. Overall, 82 European organisations, including 33 universities, 31 companies and 18 other stakeholders contributed to the project in different ways and formats, providing valuable information on their experience and views.

The paragraphs below contain the main conclusions of the project, followed by a summary list of twelve general points for all partners and a table specific for universities including main recommendations in the form of a checklist concerning collaborative doctoral education.

General remarks

This project has collected evidence from a variety of case studies, interviews and workshops involving European universities and industries engaged in collaborative doctoral programmes. These programmes have been at different stages of development, using advanced practices drawn from the experiences gained over many years to new initiatives from universities that are now seeking to build closer cooperation with their local industry. The examples and analyses in this report are put forward to foster discussion of the different approaches to collaborative doctoral education (and to doctoral education in general) and to document the views of stakeholders, specifically R&D-intensive businesses, many of which consider collaborative doctoral programmes as important channels supporting innovation and recruitment. They are also intended to inspire, illustrate good practices and highlight the common problems and the solutions found to these problems.

A secondary goal of the project has been to contribute towards overcoming a general "mindset" that, perhaps expressed in an oversimplified way, sees universities as institutions with both limited concern and capacity to interact with industry, and industry as looking only for short-term profitable solutions to current technological challenges. A university is usually not the best place to go when the requirement is for a solution of a straightforward technical problem or the provision of routine technical services. Universities provide a better return by working in long term partnerships because, by nature, this is where they can best apply their assets. While there are real structural problems that can hinder university-industry cooperation in Europe (e.g. IPR policies, social recognition of the challenges of intersectoral careers, etc.) that need to be solved at policy and political levels, there are also "mindsets" issues that can only be addressed at the individual and institutional levels. Cooperation will be better fostered when the negative perceptions of university-industry collaboration change to more positive views. This has often been achieved by identifying common research interests, establishing mutually-appropriate timeframes for addressing these interests, and seeing the results that are achieved.

Today, transdisciplinarity is seen as an essential component of innovation. Universities provide unique environments where – at least in principle – high academic standards meet and discourse flourishes across a wide range of disciplines. When universities have organised themselves to achieve this outcome, it has included a high degree of support for productive innovation. Companies in turn are becoming more aware of this characteristic of effective university campuses. Participation in collaborative doctoral

programmes is a type of partnership that is particularly valued by R&D-intensive companies, because it gives them access to a highly skilled workforce and cutting edge research that can fit into their global long-term R&D strategies. The collaboration can also provide an important source of future employees, because both the company and the candidates have the opportunity to test each other's compatibility over a number of years.

Three distinctive areas of knowledge were selected for study within DOC-CAREERS, namely Science, Engineering and Technology (SET), Biotechnology, Medical, Life Sciences (BML) and Economics and Social Sciences (ESS) with the aim of identifying common trends and patterns while taking account of different contexts. The approach proved to be appropriate because, despite the different nature and traditions of these disciplines, clear common patterns emerged concerning the setting up of collaborative doctoral programmes and issues related to the skills of doctorate holders valued in academic and non-academic doctoral careers.

The evidence provided by case studies submitted within DOC-CAREERS demonstrates that, despite the frequency with which some concerns are expressed, the concerns can all be overcome in an efficient manner, given appropriate management processes and attitudes by all parties.

Employability and Mobility of Doctorate Holders

Companies establish partnerships with universities, research centres and other companies for various reasons, including fostering innovation and supporting recruitment in key areas. In general, these forms of university-industry collaboration in Europe are mainly limited today to the more R&D-intensive sectors of business. Some companies have indicated their interest in raising their research activities through reinforced connections with universities and doctoral education, in effect replaying the types of development that took place in the early part of the 20th century before corporate R&D laboratories became widespread. Overall, there is growing awareness of the added value that university research can bring to industry and to society at large (and vice versa), and this is raising the profile of the doctoral candidates who are destined to be employed outside academia.

It has been estimated that around 50% of current doctorate holders are employed outside academia, in businesses, governments, the service sector and other education sectors, holding both research and non-research positions. The DOC-CAREERS case studies support this estimate and, while not fully comparable, are broadly in agreement with data available from national organisations such as Vitae in the UK and from international organisations such as the OECD. It is unlikely that the figure will decrease.

The main entry point of employment for doctorate holders into non-academic environments derives from the skills they have acquired through learning to perform research. Employers highly appreciate the level of scientific and technical knowledge held by doctorate holders from European universities, including their formal approach to evidence-based arguments, their analytical skills and ability to integrate knowledge from different sources and their ability to work at the frontiers of knowledge. Collaborative doctoral programmes, with their exposure to non-university environments, are seen as an excellent way to improve candidates' ability to relate abstract thinking to practical applications and vice-versa, as required for the development of new knowledge, products or services. However, companies that are innovative without necessarily focusing on research tend to recruit at masters level, which suggests that the benefits of a doctorate are not yet seen as compelling for careers that involve no formal research component.

Transferable Skills

Companies have high expectations of doctorate holders. They not only expect them to be excellent in research but also to be aware of the business environment, the value chain in the corresponding market and the regulations in place, including IPR. Partly for this reason, there has been growing attention to the need to develop so-called "transferable skills" as part of the doctoral programme.

6 Conclusions and Recommendations

The discussion on transferable skills proved to be the most controversial aspect of the DOC-CAREERS university-industry dialogue. While there was a general agreement that such skills are important, there was less consensus on the extent to which they should be a structural element of doctoral education. SMEs consulted during the project and university professors collaborating with SMEs placed a higher value in doctorate holders with the "soft skills" to complement their research capabilities at the moment of being employed. For large R&D companies, the value of hiring a doctorate holder usually lies, in the first instance, in a deep knowledge of a relevant subject and broader competencies that are likely to equip the person to handle subsequent career challenges. Partly the discussion over transferable skills reflected a "nature versus nurture" debate, and partly it was about different perceptions of institutional responsibilities and competencies. The larger companies may not consider it to be necessary to "teach" transferable skills in the university, since they can provide this training when required. Alternatively, they may believe (as do some academic supervisors) that the time spent is a diversion from research. At the same time (see previous point), these companies have their own ideas of key transferable skills, and indeed consider that one purpose of a collaborative doctoral programme is to help provide these skills.

In addition to the skills naturally acquired through research, there is a group of competencies common to all fields that is likely to make a doctorate holder more employable outside an academic context. Some of them relate to communication, negotiation and management skills, as would be expected. However, potential employers may be less aware of other skills acquired during the doctoral process, such as adaptability, the capacity to deal with complex problems and to engage in multidisciplinary work and, often, the experience of working in international environments. Mobility plays an important role in this regard, providing skills that are mastered by being exposed to different cultures and playing different roles in institutions, business and other organisations.

By the same token, the intensity of academic research means that doctoral candidates can become unduly concerned with the specifics of their own research programmes. One of the clear benefits of collaborative doctoral programmes is to provide mechanisms for candidates to observe how their own skills combine with others to achieve broader goals.

The DOC-CAREERS case studies include examples of universities with good schemes on transferable skills at the doctoral level that focus on raising awareness rather than "teaching". It is not uncommon that the university intends to ensure a minimum level of transferable skills from which they can offer additional specific courses if necessary. Organisations acting at the interface between doctoral candidates/doctorate holders and the labour market have developed activities concentrated in workshops of short duration that doctoral candidates/doctorate holders can attend on a voluntary basis.

It is important also to make explicit the implicit acquisition of skills during the doctoral period to employers, professors and to the doctorate candidate and holders. Raising the profile of the doctorate holders not only can enhance their employment perspectives outside academic environments but also can benefit society by enabling them to develop new ways of tackling technological and societal challenges.

In fairness, only a reasonable awareness of these issues can be expected from doctorate holders who have recently graduated without previous experience in industry. Companies can (and perhaps should) provide the necessary training and guidance during the initial periods in the company for the benefit of both the employer and the employee.

Regardless of their skills and competencies, doctoral candidates may have little awareness of the range of career opportunities at their disposal. Companies, universities and interface organisations that assist doctoral candidates and doctorate holders in finding their way through the labour market can contribute to this necessary promotion by providing support and more evidence of employment destinations.

Collaborative Doctoral Programmes

Each of the partners involved in a collaborative doctoral programme - doctoral candidate, university and company – is likely to set out with different objectives and expectations. Important pre-requisites are to align these objectives and expectations, while addressing the general questions of added value, risks, concerns and conditions that will set the framework for a successful collaboration and ensure high quality research. In general, it is likely that the company will be more concerned with the broader strategic context of the research programme, whereas the candidate and supervisor will be more concerned with the qualification and specific details of the project itself. Evidently, in a successful doctoral collaboration, the academic value of the research will meet the necessary academic standards for the candidate to receive a doctoral degree (hence benefiting the doctorate holder and the university); the company will consider that the work has made a valuable contribution to its own R&D objectives; and the candidate will have gained some additional skills and understanding beyond that provided by a standard doctorate.

There is widespread agreement among all stakeholders that many, if not all, of the traditional standards of academic research continue apply to collaborative doctoral projects carried out with industry. Candidates must receive degrees of known quality in an allocated and reasonable timeframe. For them, the advantage of a collaborative doctoral experience is that, in addition to gaining sound research skills, they will also gain an understanding of the business world, which will facilitate communication with industry and ultimately broaden their employability perspectives beyond the academic environment. The experience accumulated over the years by major initiatives such as CIFRE in France, CASE in UK and Industrial PhD in Denmark provides evidence of most satisfactory outcomes for the universities, companies and individuals involved. The examples illustrated by the DOC-CAREERS case studies confirmed excellence in research as a hallmark of success.

The case studies identified a variety of formulas for collaborative doctoral programmes. Nevertheless, a common pattern emerged, characterised by seven main components: strategic level of engagement in the parent organisations; role of industrial partner; selection of the doctoral research topic; additional admission requirements; formal agreement (including IPR); legal status of the doctoral candidate; composition of the supervisory committee. These components can be expressed in different ways, using different elements, and their combination defines the characteristic structures of collaborative doctoral programmes.

Initiatives may be generated by universities, industries, governments or individuals or through existing joint collaborations. Each doctoral project is unique and the partners committed are likely to have very diverse needs, economic perspectives and expectations of collaborative research, even within the same field of work. Resolving these differences is an early priority. The main advantage of organised approaches, regardless of the area of knowledge, is that they provide frameworks within which to set boundaries, define strategies and refine these strategies based on lessons learned from previous experiences.

Practitioners in all sectors and fields agreed that, independently of how well-organised a collaborative programme may be in formal terms, success also depends upon the quality of the personal component, including the ability to team up to solve problems, achieve excellent performance, and establish good levels of mutual trust between the stakeholders (doctoral candidate, industry and university researchers and managers). Cooperation processes are holistic, that is, the soft part of the relationship is very important and regular face-to-face experience is necessary in order to build durable partnerships. It is important at institutional level to permit appropriate combinations of approaches and the flexibility to modify these approaches in order to achieve the specific characteristics of a collaborative doctoral project.

These characteristics can be specified in terms

6 Conclusions and Recommendations

of three basic pre-conditions and four main operating conditions that partners willing to engage in collaborative doctoral projects should uphold. The pre-conditions include a sharing of the intended value of the research, mutual trust and a long-term approach. The operating conditions include suitable provisions for funding, joint supervision of the doctoral candidate, efficient project management and an expectation of good performance in research, eventually leading to a doctoral degree gained according to established academic standards.

Provided that the chosen elements then ensure a proper framework for the development of a doctoral thesis, it cannot be said that one approach is necessarily better or worse than another. The degree of structure of a doctoral programme, that is, how formally fixed are the initial conditions, the time to be spent in the academic and corporate environment, etc., depends basically on the source of funding (public, private), on the intended role and objectives of the industrial and academic partners, and on the cultural context within which the project will be carried out.

In general, government-driven programmes pre-determine structural elements and procedures with the aim to ensure good use of public funds and that the quality of research meets both academic standards and industry needs. These programmes also require quality assurance in the management of the doctoral process but may allow little leverage for own decision-making. Projects that take place outside the established government-driven programmes may offer more flexibility, but partners still need to find the most convenient set of elements and conditions that balance structure and flexibility, ensure excellent training, and address the needs of the doctoral candidate, the university and the company involved.

A distinctive characteristic of a collaborative doctoral education (compared to a collaborative research project) is that industry experts will take part in the supervisory committee in some significant capacity. The company can play other roles in the project, but participation in the candidate's supervision is what effectively defines the specific nature of the programme. Indeed, this role can be officially recognised, such as in the CIFRE, CASE and Danish Industrial PhD Programmes and Marie Curie Actions.

The diversity of approaches and formats in collaborative doctoral projects found by DOC-CAREERS is partly a symptom of creativity and customisation to specific environments and cultures. Nonetheless, it seems possible that better use could be made of experience gained with existing models, as part of informing the development of better future programmes. There is room for continued transdisciplinary exchange of experiences in setting up these programmes, specifically between the areas of SET/BML, which have a stronger tradition of university-business cooperation, and ESS. A general view emerged during DOC-CAREERS that SET- and BML-related programmes have tended to pay less attention to the personal development component and focussed more on the technical issues and framework agreements, while ESS-related programmes have dealt with personal development with every case but have tended to be less structured. Perhaps approaches that have been assumed to have specific disciplinary relevance can be adopted across all three fields. Organisations such as graduate/doctoral schools can be effective vehicles for exploring these possibilities.

Much of today's dialogue on university-industry collaborations tends to concentrate on knowledge areas where there has traditionally been good cooperation with industry such as SET and BML. The ways in which the ESS and SET/BML communities talk about and perceive their challenges seem different, but this could just reflect a different stage of development, as SET/BML university-industry cooperation was some time ago. Issues such as the recognition of the collaborative activities in the CV of university professors and researchers, and mobility factors related to age, gender, location, family, etc. are common to all fields. Efforts can be made from all sides, academic and industry and policy-making bodies, to raise awareness and devise improvements.

Doctorate holders from collaborative projects gain enhanced career opportunities outside

academic environments with respect to those in traditional programmes when their research has included placements in industry. Placements are seen as one of the most important contributions that an industry can offer to the education of a doctorate holder wishing to obtain insight into the business world (e.g. from using business labs and participating in business meetings to having lunch in the canteen). How much a doctoral candidate can embed in the daily life of the company will depend on company policy but the sole fact of being exposed to the industrial dynamics is already a learning experience of itself.

Collaborative doctoral theses are a good way to foster university-industry relations and mutual understanding. Most of the universities contacted in the course of this project report completion rates that are over 90%. The successful candidate exposed to both university and business environments during 4 years of research training learns to deal with different interests and operating modes and thereby becomes a more effective link between university and industry.

Views of Stakeholders

DOC-CAREERS university case studies highlighted a number of benefits from collaborative doctoral programmes such as promoting innovation, entrepreneurship and social responsibility, incorporating industry input to university research, gaining awareness of industry's technological challenges and contributing to sustainable funding for research.

In analysing the impact of collaborative doctoral education, DOC-CAREERS university case studies with successful experience in collaborative doctoral thesis reported tangible and intangible benefits for the persons directly involved in the project – doctoral candidate, university and industry supervisors, to the institutional and organisational benefits and to a broader positive impact on the city/region. For example, when looking for employment, doctorate holders take with them the reputation of a good collaborative scheme that funded the research and the names of the university and company involved.

Other positive impacts on the university included enhancing appreciation of doctoral studies and increased number of doctoral graduates, improving university-industry relations in general, improving institutional profile and outreach, attraction of more funding for research - which in its turn enhances autonomy, and attraction of students from other regions and internationally. Concerning the university city/region, the main benefits derived from these partnerships included building regional synergies to create critical mass for research, retaining and attracting students from outside the region, attracting and retaining businesses and creation of employment.

The doctorate candidates and holders who participated in DOC-CAREERS reported some main concerns and challenges compared to their peers in more traditional doctoral programmes. They include coping with the potentially-different levels of commitment of different supervisors, balancing their time properly between university and industry activities, having to draft multiple reports with the same research outcomes in order to satisfy different academic and industrial needs, and delays in publication required to satisfy corporate clearance procedures.

In general, these doctoral candidates value the expanding range of employment opportunities outside academic environments and agree that, as in any other kind of employment, different positions may require different sets of skills. However they questioned if the doctoral system as such really needs to change to incorporate specific training on transferable skills or if the issue can be re-thought and linked to further specific training, e.g. on managing research.

Companies that are experiencing a general migration from the "closed innovation" model to "open innovation" are also becoming more aware of the state-of-the-art research that is carried out in research institutions, and more selective and discerning of the types of collaboration that will prove to be effective. This model of "open innovation" is seen as a good means of bringing the public and private research sectors closer together while also raising standards. From the enterprise point of

6 Conclusions and Recommendations

view, it is apparent that business approaches to universities are evolving from looking for a single point of entry to university research to seeking the right expertise worldwide. This scheme is developed especially by large R&D companies and some High Tech Small and Medium Enterprises (SMEs). A remaining major question mark is how SMEs can develop more and better strategies to enhance their access to university research and resources.

The companies interviewed in DOC-CAREERS illustrated a diversity of innovation profiles in terms of the nature of their innovation processes – technological, non-technological, procedural, organisational, design or marketing-oriented. They operate in a variety of sectors and their sales volumes are also very diverse. Yet, the general views they expressed on what they expect from doctorate holders are quite uniform, as are their perceptions of the strengths and weaknesses of doctorate holders in their first time in an industry environment. In general, they are very pleased with the knowledge and research skills of doctorate holders educated in Europe, but also pointed to the need for greater communication skills and the limited awareness of intellectual property issues and understanding of how businesses operate.

In general, R&D-intensive companies of all sizes are convinced of the importance of establishing long-term trust-based relationships with universities. SMEs have an important role in developing the local economy – and they can encourage doctorate holders to play stronger roles within local society. However, companies should avoid recruiting doctorate holders for inappropriate positions and also understand how to use collaborative doctoral programmes in ways that take advantage of the distinctive skills, resources and missions of the university sector.

Data Tracking

The Working Group on Data Tracking reported on the paucity of examples of institutional data tracking. Organisations which participated in the exercise highlighted the benefits of sound tracking, including exploring the skills and competencies that doctorate graduates need, informing curricula development, attracting future doctoral candidates, increasing the social standing of doctorate graduates and promoting the academic status of universities. Main challenges relate to the generally low response rates, question marks over the representativeness of coverage of academic versus non-academic career paths, and the difficulty of comparing data outcomes from different institutions. While new (soft) tools are required to address some of these challenges (e.g. making more use of alumni networks), considerable progress can be made simply by adopting existing good practices and taking advantage of technological developments in software.

The evidence collected and views expressed during the DOC-CAREERS project by universities, companies and other stakeholders concurred that career paths of doctorate holders in research and non-research positions are extremely diverse, in both academic and non-academic organisations. Except for a few trends in academia or in industry, it is very difficult to talk about typologies of doctoral careers. It is more appropriate to talk broadly about the career or employment opportunities that are open to people who have been highly trained in the methods of research. In this sense, institutional tracking of the professional destinations of their doctoral graduates can prove of great value to universities to inform curricula and develop better their specific missions and profiles in doctoral education.

Consequently, it is recommended that data tracking should form part of the institutional framework for doctoral programmes, whether conventional or collaborative in nature.

Enhanced Dialogue and the Role of Government

There is a widespread belief that providing more and better prepared doctorate holders for employment in business environments will enhance European opportunities to become more competitive at a global scale. This study has not attempted to judge the correctness of that belief, but does find that improving the

attractiveness of the research career in Europe will depend upon an enhanced science-society dialogue to foster greater understanding of the potential benefits and opportunities generated by collaborative research between university and industry, while recognising, weighing-up and addressing risks and concerns.

The enhanced dialogue required to achieve more effective university-industry cooperation can be promoted at many levels. Investing in developing the soft part of the relationship – proximity for easy opportunities of meeting, one-to-one dialogue, etc. – is essential and such platforms for dialogue should be developed: obviously between university and industry but also within university disciplines and industrial sectors to favour trans-disciplinary and trans-sectoral exchange. Another interesting dialogue with huge potential could be between university/industry partnerships and the general society (e.g. through Chairs, student placements, "ambassador" type initiatives with primary and secondary schools). Partners in collaborative schemes should value the tangible assets (e.g. publications, contracts, exploitation rights, economic benefit) as well as the intangible (e.g. human capital, reputation, societal benefit).

The committed support of governments is also essential, as facilitators of university-industry collaboration and, specifically, in doctoral education, and should include initiatives to address structural issues such as those mentioned above that are outside the capacity of the individual research actors. Many DOC-CAREERS collaborative case studies demonstrated that collaborative programmes require for their sustainability of the programmes the continued support from governments and funding bodies. Government funding support and its necessary accountability requirements provide organisational structure and help to enhance quality. In general, this structure results in better joint supervision and placements that prove to be satisfactory for all parties: university, industry and doctoral candidates. Public support is, furthermore, much more important for SMEs than for large R&D intensive companies that have the resources to manage on-going collaborations.

Final Remarks

Dialogue between university and industry on collaborative research is reaching a level of maturity that provides opportunities for effective action to promote durable relations between the academic and business worlds. There are distinctive European ways of responding to the university-industry collaboration challenges which need further development and may offer a different approach to that practiced in North America and other regions of the world. At the policy dialogue level several important European initiatives are already developing to respond to the challenges. These include the European Commission Communication on "Better Careers and More Mobility: a European Partnership for Researchers", Marie Curie Actions, the European Commission Recommendation "on the Management of Intellectual Property in Knowledge Transfer Activities and Code of Practice for Universities and Other Public Research Organisations", the Responsible Partnering Guidelines and the EUA Council for Doctoral Education (EUA-CDE)[48]. DOC-CAREERS outcomes will feed the policy dialogue and they are the basis for further work by EUA and other interested organisations.

The evidence collected during DOC-CAREERS has demonstrated that universities and enterprises share many views on the opportunities, challenges and barriers associated with university-industry cooperation. In this sense, the "diagnosis" of the situation is sound and the common barriers in Europe are well identified. Nonetheless, the DOC-CAREERS case studies also confirmed that these barriers can be overcome. There are no "one-size-fits-all solutions" and successful approaches tend to incorporate local or regional cultural specificities as captured in the phrase "the way we do things here". However, all successful approaches are based on mutual trust and understanding, and not on an expectation that one party should contribute to another's objectives. In order to assess the true importance of this diversity, follow-up actions are required which look more specifically at how universities work with their regional partners in doctoral education.

[48] EUA Council for Doctoral Education, http://www.eua.be/eua-council-for-doctoral-education/

6 Conclusions and Recommendations

Other areas for further review in the field of university-industry collaborative doctoral programmes include doctoral supervision and strategies for the recruitment and retention of doctoral candidates. It is also important to make the implicit acquisition of skills in doctoral programmes more explicit to students and employers. The skills of creative workers acquired during research training (e.g., capacity to deal with complex problems, capacity to work well in international environments, thinking "out of the box"), can serve the knowledge society by developing new ways to deal with problems and finding imaginative solutions.

Twelve messages for developing collaborative doctoral programmes

General points for all partners:

1. Identify knowledge/technological needs and challenges which need R&D input
2. Exchange views on knowledge/technological challenges with university/industry
3. Plan medium-long term R&D strategy (e.g. within five years)
4. Develop high quality research proposals
5. Know the costs of your research and identify funding sources
6. Raise your awareness of the respective research environments in which to collaborate in your field (university, industry)
7. Develop/Participate in fora for soft ways of interaction between students, researchers and industry experts with good research content (conferences, fairs, etc.)
8. Organise small-size highly-specialised workshops/meetings pooling experts from different research fields and sectors
9. Seek the right expertise to assist you (IPR issues, contractual issues, etc.)
10. Formalise doctoral collaborations in solid and fair agreements combining structure and flexibility
11. Consider physical proximity as an asset to develop mutual trust - promote face-to-face dialogue
12. Commit to excellence in doctoral education, research and management

Source: EUA DOC-CAREERS Project

Collaborative Doctoral Programmes - University Recommendations and Check List

Why should universities get involved?
See table 3.3-2 with Motivations/Benefits/Challenges and related explanations, recommendations from stakeholders and impact assessment (Sections 3.3., 3.6. and 3.7., respectively).

With whom?
With industry partners which:
- Value your R&D
- With a supervisor in the company you trust and had experience
- Establish a fair agreement
- Can meet/dialogue as necessary to monitor the progress and solve problems when they arise

With a doctorate candidate who, in addition to proper credentials:
- Is motivated to work in industry environments, even if his/her career preferences were in academia
- Has the ability, or the potential to develop it, to integrate and operate with two different mindsets and cope with different types of pressures and timeframes

What could we do for better adjustment?
Universities for themselves as an institution:
- Know the cost of your research (full cost model)
- Plan a long-term research strategy and the role that industry would play in it
- Support developing personal relations of top researchers with industry
- Develop platforms for regular soft dialogue with industry with strong R&D content, professors, researchers, doctoral candidates: seminars, talks, job fairs, company visits
- Develop internal policies for: IPR, recognition of research activity with industry in faculty career development, ethical codes, etc.
- Develop structured schemes to formalise collaborative doctoral projects: ensure all the necessary components are there, especially supervision for the doctorate candidate by the employer and funding for his/her salary and research, IPR and ethical issues
- Develop effective management, customised to industry
- Develop institutional support to faculty activities with industry: know-how of university-industry relations (e.g. guidelines), workshops for exchange of experiences, legal support
- Adapt space in university facilities for confidential research if necessary
- Be aware of the transferable skills of your doctorate graduates
- Track the employment destination of your doctorate graduates and identify role models
- Make the implicit acquisition of skills on PhD programmes more explicit to students and employers
- Share your case with peer universities
- Develop indicators to monitor and assess progress
- Analyse recruitment/retention rates for doctoral candidate and draft strategies accordingly

Universities to their faculty staff and researchers:
- Focus on good quality research
- Identify structural problems in your university such as unawareness of know-how of university-industry relations, on IPR, lack of incentives for faculty and provide the necessary tools to address the issues
- Promote institutional commitment
- Raise awareness on transferable skills and career perspectives of doctorate holders
- Raise awareness of university assets: internal policy, administrative support, legal support
- Keep faculty informed on own success stories, let them know you can support them
- Disseminate employment outcomes of your doctorate graduates and identify role models together with faculty to inform curricula

Universities to doctoral candidates:
- Provide necessary framework for doctoral candidates to develop properly their research: access to training, material, know-how, supervision, peer-to-peer contact, etc.
- Raise awareness of the skills he/she is likely to acquire during the doctoral period and career opportunities
- Disseminate employment outcomes of your doctorate graduates
- Raise awareness of IPR issues and protect the right to publication of those outcomes with academic value
- Foster informal contact with industry: let the doctoral candidates organise activities with industry under your guidance
- Allow candidates to prepare presentations of their work with the presence of industry
- Others of your own….

7 Annexes

7.1. Annex 1: List of Organisations, Participants and Contributions

HIGHER EDUCATION INSTITUTIONS

Aarhus School of Business, Aarhus University, Hans Henrik Edlund. Director of PhD Programmes, Denmark - University Case Study

Delft University of Technology, Hans Suijkerbuijk, Policy Advisor & Els Noorda, Management Trainee, The Netherlands - University Case Study

Erasmus Research Institute of Management (ERIM), Erik van Heck, Professor Information Management and Markets, ERIM Director of Doctoral Education, The Netherlands - University Case Study

ESADE Business School, Nuria Agell Jane, Departament de Mètodes Quantitatius, Catedràtica URL, Spain – University Case Study

European University Institute, Andreas Frijdal, Head of the Academic Service, Italy – Tracking Methodology Study and Member of the Working Group on Tracking

Frankfurt Graduate School for the Humanities and Social Sciences (FGS), Helmut Brentel, Germany - Workshop Participant

Ghent University, Karen Vandervelde, Research Policy Advisor, Belgium - Tracking Methodology Study and Member of the Working Group on Tracking

Hanken Swedish School of Economics and Business Administration, Maj-Britt Hedvall, Research Director, Finland – University Case Study

Imperial College London, Bernard Morley / IDEA League (Imperial College London, Delft University of Technology, ETH Zurich, Aachen University RWTH) – Transferable Skills

Katholieke Universiteit Leuven, Klara Gijsbers, Research Co-ordination Office, Belgium - Tracking Methodology Study and Member of the Working Group on Tracking

London School of Economics and Political Science, Rhiannon Thompson, Assistant Academic Registrar (Research Degrees), UK – Tracking Methodology Study

Masaryk University, Jaroslav Andrle, Head of Research and Development Office, Czech Republic - University Case Study

Matej Bel University, Jana Kučerová, Associated Professor, Department of Tourism and Hospitality Faculty of Economics, Slovakia - University Case Study

Mykolas Romeris University, Jolanta Grigaliūnaitė, Deputy Director of Research Directorate, Lithuania - University Case Study

National and Kapodistrian University of Athens, Klas Eric Soderquist, Greece - University Case Study

Newcastle University, Robin Humphrey, Director of Postgraduate Research Training, UK - University Case Study

Ruhr-Universität Bochum, Thomas Koch, Scientific Coordinator, Germany – Transferable Skills

Simula School of Research and Innovation AS, Kristin Vinje, Director, Norway - University Case Study

Technische Universität Ilmenau, Erich Runge, Vice Dean Faculty of Mathematics and Sciences, Germany - University Case Study

Universitat Autònoma de Barcelona, Antoni Mendez, Advisor to the Vice-Rector for Graduate Studies, Spain - Tracking Methodology Study and Member of the Working Group on Tracking

Université Pierre et Marie Curie, Paule Biaudet, Head of the House of Doctoral Schools, France – University Case Study

Università degli Studi di Milano, Vincenzo Ferrari, Rector, Italy - Workshop Participant

Universitat Rovira i Virgili, Josep Font, Departament d'Enginyeria Quimica, Escola Tecnica Superior d'Enginyeria Quimica, Spain - Steering Committee Member

University of Cagliari, Aldo Pavan, Dean of the Faculty of Economics, Italy - University Case Study

University of Dublin, Emer Cunningham, Project Manager, Structured PhD Programmes, Ireland – Workshop Participant

University of Helsinki, Finland - Tracking Methodology Case Study

University of Jyväskylä, Sirkka-Liisa Korppi Tommola, Head of Research Finland – Tracking Methodology Case Study and Member of the Working Group on Tracking

University of Paderborn, Eckhard Steffen, Director of Graduate Studies, Germany - University Case Study

University of the West of England, Stephen Hagen, Director of Research, Business and Innovation, UK - Steering Committee Member

University of Wales - Bangor, Bryn Jones, Office Manager, UK - University Case Study

Uppsala Universitet, Jaan Grunberg, Assistant Professor, Department of Business Studies, Sweden - University Case Study

Utrecht University, Hans Sonneveld, Director of Research, The Netherlands - Tracking Methodologies Case Study

VŠB-Technical University of Ostrava, Petr Noskievič, Prorektor,Czech Republic - Workshop Participant

ENTERPRISES

(Site of R&D center interview)

Arçelik, Fatih Ozkadi, R&D Manager – Mechanical Technologies, Turkey

Arcelor Mittal, Danièle Quantin, HR and Quality Manager, France

Arjo Wiggins Appleton, Eric Buhannic, T&I HR Manager, France

Bekaert, Lisbeth Jacobs, Global Recruitment and Selection Manager, Belgium

BioCydex, El Mustapha Belgsir, Chief Executive Officer, France

Corus, René Duursma, University Liaison Manager Corus RD&T, The Netherlands

Dow Corning, Janet Blakely, Science & Technology HR Business Partner, UK

Eurofins Scientific, Jérôme Gillyboeuf, Directeur des Ressources Humaines, France

Haldor Topsøe, Hans Chr. Dibbern, Deputy Division Manager, Denmark

IBM, Hans Hofmann, Human Resources Manager, Switzerland

Infineum International, Lee Sprung, Technology HR Executive, USA-UK

Lafarge, Philippe Michaud, Organisation and Human Resources Director, France

L'Oréal, Catherine Hautin-Ferrero, France

Microsoft Research, Andrew Herbert, Managing Director, UK

Nestlé, Jérôme Dano, Head of Human Resources, Switzerland

Novo Nordisk, Børge Diderichsen, Vice President, Denmark

Océ, Frans Coolen, Head, Personnel Dept R&D, The Netherlands

Oridis Biomed, Peter Hecht, CEO, Austria

Outokumpu, Niilo Suutala, Senior Vice President, R&D, Finland

Philips, Emile Aarts & Dr. Lisette Appelo, The Netherlands

Procter & Gamble, John Crompton, R&D Recruiting in Europe, UK

Renault, Gonzalo Hennequet, Head of Energy Synthesis & Energy Storage Department, France

SCA, Agneta Lowek, HR Manager, Sweden

Schlumberger, Olivier Peyret, Vice President, University Collaborations & Recruiting, France

Siemens AG, Dietmar Theis, Germany

7 Annexes

Solvay, Léopold Demiddeleer, Corporate R&D & NBD Director, Belgium

Stora Enso, Jukka Kilpeläinen, Senior Vice President, Corporate R&D Chemistry, Finland

Swisscom, Peter Bachmann, Head of Human Resources, Swisscom Innovations, Switzerland

SYNPO, Martin Navratil, Chairman of the Board and Managing Director, Czech Republic

Thales, Jean-Yves Colombel, DRH de la Recherche & Technologie, France

VTT Technical Research Centre of Finland, Marja Lindgren, HR Manager, Finland

OTHER PARTNERS

ABG (Association Bernard Gregory), Catherine Vilkas & Maïté Brunel, France – Transferable Skills and Employability

CESAER (Conference of European Schools for Advanced Engineering Education and Research) Peter Schaft – Rector, Technische Universitat Ilmenau, Germany – Workshop Participant

Comunidad de Madrid, Emilio Fernandez Galiano Ruiz, Head of Area of Investigating Promotion of Personnel, Main directorate for Universities and Investigation, Spain – Workshop Participant

Danish Ministry of Science, Technology and Innovation, Morten Bovbjerg, Senior Advisor, Denmark – Workshop Participant

DG Research Emmanuel Boudard – Steering Committee Member; Adeline Kroll – Invited Member of the Steering Commitee

EDAMBA (Network of European Doctoral Programmes in Business Administration) Maj Britt Hedvall, Research Director, Finland – Mediator university-business case studies

EIRMA (European Industrial Research Management Association), France
Andrew Dearing - Member of Steering Committee and Mediator of the business case studies;
Edwige Chassagneux, CIFRE Doctoral Candidate – Mediator in the business case studies and invited observer of the Steering Committee

EURODOC, Timothy Brown – Member of Steering Committee and Mediator of the Doctoral Candidates Case Studies;
Koen H. van Dam, doctoral candidate, Former President EURODOC

EFMD (European Foundation for Management Development) Christophe Terrasse, Associate Director - Workshop Participant

EMBO (European Molecular Biology Organization) – Gerlind Wallon, Young Investigator Programme Manager, Germany – Workshop Participant

Helmholtz Association, Susan Kentner, Germany/Brussels - Transferable Skills

HESA (Higher Education Statistics Agency), UK – Tracking Methodologies Study

LERU (League of European Research Universities) Katrien Maes, Director of the office and Policy Officer for doctoral studies and research careers, Belgium – Workshop Participant

Marie Curie Actions – European Commission – Tracking Methodologies Study

NIFU STEP, Studies in Innovation, Research and Education, Norway – Agnete Vabo, Head of Research – Transferable Skills

OECD (Organisation for Economic Co-operation and Development), France - Laudeline Auriol, France – Tracking Methodologies Study and invited observer of the Steering Committee

UK GRAD Programme, now Vitae, Janet Metcalfe, UK - Tracking Methodologies Study and Chair of its Working Group; invited observer of the Steering Committee

VSNU (Association of Universities in the Netherlands), Hugo Levie, The Netherlands - Workshop Participant

7.2. Annex 2: Members of Project Committees

Steering Committee:

John Smith, EUA (Chair)
Lidia Borrell-Damian, EUA (Project Co-ordinator)
Emmanuel Boudard, European Commission
Tim Brown, EURODOC
Andrew Dearing, EIRMA
Josep Font-Capafons, Universitat Rovira i Virgili, Spain
Stephen Hagen, University of the West of England, UK

Invited observers:
Laudeline Auriol, OECD
Edwige Chassagneux, EIRMA
Adeline Kroll, European Commission
Janet Metcalfe, UK GRAD Programme, now Vitae

Tracking Working Group:

Janet Metcalfe, UK GRAD Programme, now Vitae, Chair of Working Group
Lidia Borrell-Damian, EUA
Andreas Frijdal, European University Institute, Italy
Klara Gijsbers, K.U. Leuven, Belgium, LERU member
Sirkka-Liisa Korppi-Tommola, University of Jyväskylä, Finland
Prof. Antoni Méndez, Universitat Autònoma de Barcelona, Spain, ECIU member
Karen Vandervelde, University of Ghent, Belgium

7.3. Annex 3: About the Questionnaires

As explained in Chapter 2, four questionnaires were used in the study:

- Questionnaire and Guidelines for University Case Studies
- Questionnaire and Guidelines for Enterprises
- Questionnaire and Guidelines for Doctorate Holders
- Questionnaire for the Tracking Study.

The First and Second Workshops and the first meeting of the Tracking Working Group informed the questionnaires, which addressed issues in the following categories:

Views from Stakeholders:

- What are the motivations and incentives for university and external partners to establish cooperation in doctoral schemes?
- What are the main characteristics of these initiatives?
- What are the funding sources for these schemes?
- What are the views of the different stakeholders?
- What recommendations can be given to universities and employers to establish cooperative doctoral programmes?

Doctoral Programmes in Cooperation with Business:

- Which good practice or models of cooperation can be pointed out as recommendations?
- How are the characteristics of these schemes different depending on the field of knowledge?
- How do career opportunities differ depending on the field of knowledge (i.e. SET, BML, ESS)?
- What are the benefits of these programmes?
- How important is the transferable skills training?
- Is the extent of inter-sectoral mobility appropriate? Is it valued by employers?
- Are these programmes sustainable?

Data Collection and Tracking Systems of Doctorate Holders Careers:

- What would be appropriate methodologies to track doctorate holder careers?
- Which are the benefits of collecting data for universities?
- How can the data collected be of use for universities? And for employers?
- How to obtain quality feedback from stakeholders?
- What are the present and future data needs?
- What recommendations can be given for appropriate tracking of doctorate holder careers?

7 Annexes

Impact of University/Business Doctoral Programmes on the Employability of Doctorate Holders:

- Do these programmes enhance career opportunities for doctorate holders?
- How to enhance the employability of doctorate holders?
- What are the difficulties and achievements in embedding transferable skills training in doctoral education?
- Are doctorate holders employed where they can make the best use of their skills and competences?
- How can the profile of the doctorate holder be promoted among employers?

7.4. Annex 4: Employment Destinations of Doctorate Holders

Employment outcomes from the doctoral initiatives reported in DOC-CAREERS Case Studies

Some of the university case studies included information on the employment destinations of their doctoral graduates between 2004 and 2007. The following list includes a selection of data representative of the employment destinations normally one year after earning the doctoral degree. The data below are not homogeneous, hence not comparable, because the level of availability was different in every institution, some from programmes which specifically included industry and others referring to the entire population of doctoral graduates. For simplicity purposes, data have been aggregated to give qualitative evidence of the employment outcomes of doctoral graduates.

- Cagliari University, with limited collaborative doctoral education, reported most of its doctoral graduates between 2004 and 2007 as employed mainly in the service sector, both as researchers and non-researchers.
- Erasmus ERIM reported most of its graduates between 2004 and 2007 found employment the HE sector. Those who were employed in business-enterprises, did so in large corporations.
- ESADE reported about two thirds of its doctorate holders graduated between 2004 and 2007 to be employed in the HE sector.
- Hanken Swedish School of Economics: From 96 doctorate holders graduated between 2004 and 2007 from schemes in cooperation with industry:
  . Employed as researchers: 23%, mainly in the HE sector
  . NOT employed as researchers; 27%, mainly in the business-enterprise sector
  . Employed in the service sector: 50%, quite scattered in all categories within.
- KU Leuven: In an exit survey conducted in 2005 of doctoral and post-doctoral researchers leaving the university:

Out of 430 researchers, 60% found a new job

As researchers:
. 33% abroad
. 19% in the industrial sector
. 12% in a research institute

As NON-researchers:
. 10% in the industrial sector
. 10% in a research institute
. 8% in the governmental sector
. 8% other

Out of 141 post-doctoral researchers, 81% found a new job

As researchers:
. 32% abroad
. 19% in the industrial sector
. 11% in a research institute

With Permanent academic positions:
. 5% abroad
. 5% another research institute

As NON-researchers

. 11% in the industrial sector

- Masaryk University: According to data provided by Masaryk University (Czech Republic), from the 505 doctorate holders graduated between 2004 and 2007, within the first year after graduation those who were

Employed as researchers:

. HE sector (including post-docs): 33-39%
. Business-enterprise: 13-22%
. Government: 8-10%
. Private non-profit organisations: 29-36%
. Other organisations in the education sector: 4-8%

NOT employed as researchers: 31-39% went to companies with more than 100 employees

Employed in the service sector: public "administration and finance" was the largest sector of destination, employing 53-59%.

- Matej Bel reported that most of its doctoral graduates between 2004 and 2007 were employed in the HE sector.
- Mykolas Romeris reported all doctoral candidates at the university are employed elsewhere in the labour market during their doctoral research. Because of the lack of government support in social sciences, candidates have a job outside academia and conduct their doctoral research in parallel. It was estimated that doctoral candidates can only dedicate 25% of their time to the doctoral research. The difficulties related to combining work and research is one of the main causes of incompletion of the doctoral degree. However, those who graduate tend to stay working for the same company as before and they are offered a higher salary. Only a small proportion of doctorate holders go to academia.
- Paderborn University reported 2/3 of its graduates to be employed in non-academic sector between the years of 2004 to 2007 after earning doctoral degrees within the scheme of Dynamic Intelligent Systems (IGS) in close cooperation with businesses.
- TU Delft reported that the 60 TRAIL graduates between 2001 and 2006 have pursued careers in a wide variety of directions:

. Government (national, provincial and local): 11%
. Self-employed: 2%
. Private company: 25%
. Research institute: 7%
. University: 55%

"Thus more than half of these graduates stayed active at a university, about a third of them stayed at the institution where they obtained their degree and the other two thirds were employed at another university in The Netherlands or abroad. Most of them now work as assistant professors or associate professors, whilst some are research assistants. Two early TRAIL graduates are now full professors. Fewer than 5% of those working at universities hold non-academic positions such as managers and administrators".

- UPMC: Three months after termination of the CIFRE contract, UPMC-CIFRE graduates from Pierre et Marie Curie University between 2004 and 2007 were employed:

HE sector:

. 10%-25% post-doctoral position
. 6%-10% research institutions

Business-enterprise:

. 25%-50% by CIFRE host company;
. 12%-20% by other companies

Unknown destination: 10% to 25%

Looking for jobs: 10% to 25%

7 Annexes

7.5. Annex 5: Methodology for the Estimation of the Innovation Index of Companies

The OECD study[35] based on which the innovation index was estimated included both technological and non-technological indicators to account for innovation in areas other than products and technology, i.e. services, design and management processes (Table 7.5-1). The paper classified innovation in organisations in two steps, the first grouping several innovation activities in 5 "Factors" and the second combining one or more "Factors" in 5 "Clusters". For instance, in the first step, a company which innovates in goods, services and processes is innovative in Factor 2 "Product and process innovation"; a company innovating in management techniques, organisational structures and marketing concepts is innovative in Factor 3 "Organisational structures/strategies"[49]. In the second step, a company active, for example, only in Factor 2 can be defined as a "Market Innovator" (Cluster 1) and a company innovative in all factors, would be a "Super Innovator" (Cluster 3).

Due to the complexity of the second step of the methodology, a simplified version based only on the first step was used to estimate an innovation index which could serve the analysis of the survey outcomes in accordance to DOC-CAREERS objectives. The procedure was as follows: for each EIRMA-member company, 1 or 0 points were allocated, as appropriate, to every innovation activity of the list in Table 7.5-2, i.e. "Innovation in goods", "Innovation in services", etc. In this way, every company had a number of points in each of the 5 Factors (Table 7.5-2). A total innovation index was calculated for every company by adding the score in all Factors, from which a scale of 1 to 14 points resulted. A score of 1 denotes relatively low innovative companies (or companies which focus their innovative activity on a single factor) and a score of 14 indicates relatively high innovative companies (or multi-factor innovative companies).

[49] In the second step, for example, a company active only in Factor 2 can be defined as a "Market Innovator" (Cluster 1) and a company innovative in all factors, would be a "Super Innovator" (Cluster 3).

Table 7.5-1 Technological and non-technological innovation factors and clusters

Exploratory factors analysis

Innovation activity	New and diffused technology, plus training	Product and process innovation	Organisational structures/ strategies	Protection related to design	Expenditure on design, marketing
Innovation in goods					
Innovation in services					
Novel product innovation					
Process innovation					
Novel process innovation					
Corporate strategy					
Advanced management techniques					
Organisational structure					
Marketing concepts or strategies					
Intramural R&D					
Acquisition of R&D					
Acquisition of machinery					
Acquisitions of external knowledge					
All forms of design					
Registration of design					
Copyrights					
Complexitiy of design					
Training					
Market introduction of innovations					

Cluster analysis

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
	Market Innovators	Low Activity (low level of innovation activity)	Super innovators	Design based development	Management innovators
Factor 1 (New and diffused technology, plus training)					
Factor 2 (Product and process innovation)					
Factor 3 (Organisational structures/strategies)					
Factor 4 (Protection related to design)					
Factor 5 (Expenditure on design, marketing)					

Source: OECD[35]

7 Annexes

Table 7.5-2 Scheme of the set of data for the final selection of the companies

	Country	Sector	Sales	Total	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
Company A	…	…	…	2	1	1	0	0	0
Company B	…	…	…	3	1	2	0	0	0
Company C	…	…	…	4	3	1	0	0	0
Company D	…	…	…	4	2	1	1	0	0
Company E	…	…	…	6	2	2	0	2	0
Company F	…	…	…	7	2	2	0	0	1
…	…	…	…	8	2	2	1	1	1
…	…	…	…	12	4	4	2	2	0
Company X	…	…	…	13	4	3	3	2	1
Company Y	…	…	…	14	4	3	3	3	1

Source: EIRMA

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