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BY LIDIA BORRELL-DAMIAN, RITA MORAIS AND JOHN H. SMITH

EUA
European University Association

This project has received funding from the European Union's Seventh Framework Programme through a Support Action within the 2008 People Work Programme under grant agreement no 241262.

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COLLABORATIVE DOCTORAL EDUCATION IN EUROPE: RESEARCH PARTNERSHIPS AND EMPLOYABILITY FOR RESEARCHERS

REPORT ON **DOC-CAREERS II** PROJECT

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FOREWORD

It is often said today that future European competitiveness in the globalised economy will depend largely on its ability to train and attract highly qualified professionals. Furthermore, Europe's capacity as a leading region in scientific and technological development needs to be translated more effectively into economic and social innovations. Such innovations identify and develop new "cutting-edge" sectors of the economy and re-orient the existing sectors, both public and private, to meet the challenges of the rapid pace of transformations in the 21st century in terms of technological development, environmental and climatic conditions and, not least, demographic change.

Universities are one of the essential cornerstones in which building a successful economy and society to tackle these 21st century challenges will be achieved. In their role as both initiators of new knowledge through basic research and teachers and guardians of existing knowledge, universities are educating people with the skills to meet these challenges. In doing so, "Employability" and "Partnerships" are key concepts that drive universities' concerns to adapt their education and research missions and strategies to meet societies' need for new knowledge and expertise, increasingly complex and interdisciplinary in character, for today's graduates.

For these reasons, EUA has prioritised doctoral education as an area of importance in working with its university membership to study the development of doctoral programmes involving greater critical mass, the development of transferable skills and other reforms, and to disseminate good practice through peer-to-peer learning. In addition to its establishment of the EUA Council for Doctoral Education for this purpose, EUA through its research and innovation activities has pioneered work on the analysis of the state of play of collaborative doctoral education, its characteristics and the conditions under which it can continue to prosper.

The DOC-CAREERS II project engaged a significant number of universities (ranging from technical universities to large public universities and small regional universities) and their partners (industry/business, both large and small, and public authorities) who were working together in building successful collaborative doctoral research programmes. We were pleased to be able to draw fully on the support and participation of not only the academic research staff and doctoral candidates but also their business partners who were actively involved in the project. Hence, we are confident that the findings are both rigorous and based on consensus and therefore should be of value and command attention from universities who wish to develop such programmes in the future and policy makers in education, research and innovation at regional, national and European levels.

At the time of writing, in early 2015, European investment in training of young researchers as future researchers, entrepreneurs and employees to meet the economic and societal challenges facing us remains weak compared to other global regions. This report provides clear evidence on an important target area for priority future investment of research and innovation resources.

Lesley Wilson
Secretary General
European University Association

ACKNOWLEDGEMENTS

Many participants from universities, companies and other external partners provided generously their knowledge and expertise in the process of conducting this project. Also, importantly, they continued to do so in the period that followed the completion of the project when its findings have been brought into the European policy process in many meetings and events in Brussels and elsewhere. Throughout these years we have been most grateful for this deep commitment on the part of many colleagues who have worked with us. It is not possible to name you all here but all your universities, companies and other organisations are listed at the end of the report. We extend also our thanks in particular to the members of the Steering Committee who gave excellent direction and oversight to the project and kept us, the project team, firmly on track! In addition, we appreciate the valuable support and advice provided by the European Commission DG Research and Innovation Directorate staff responsible for the project dossier.

Dr Lidia Borrell-Damian and **Dr John H. Smith**
European University Association

EXECUTIVE SUMMARY

The project "Promoting Collaborative Doctoral Education for Enhanced Career Opportunities" (DOC-CAREERS II) looked at how universities work with their business and other non-university partners in establishing and taking forward research projects in the framework of doctoral education. It aimed at reflecting on good practices in university-business relations, with particular emphasis on regional dimensions, as well as exploring the employment prospects of doctorate holders and how collaborative schemes can enhance their career prospects. The project also engaged a variety of stakeholders from different European countries and from varied knowledge areas (Science, Engineering and Technology – SET; Biotechnology, Medical and Life Sciences – BML and; Economics, Social Sciences and Humanities – ESSH).

This report points to the existence of a variety of collaborative models, shaped by the characteristics of the research project, the profile of the university and the company, and the regional context. The potential importance of collaborative doctoral education for regional development is highlighted. It demonstrates that the establishment of university-business partnerships is based upon proximity among the different partners (e.g. geographical proximity, shared language), a common understanding of the regional context, and the presence of appropriate policies and legal frameworks which are all important elements in developing and sustaining successful partnerships.

Throughout the project, it became clear that regions which sought to build their competitiveness through innovation from university R&D did indeed value collaborative doctoral programmes and the skills that doctoral candidates acquire through their education and training. These regions establish policies that support research collaborations and commit resources through local/regional public programmes and encourage the participation of local SMEs. Some of these regions also encourage applications for funding from European and worldwide competitive calls and push for mobilising private funding.

For universities, collaborative doctoral degrees entail the same high standards for scientific quality of research as that required of a doctorate in a traditional doctoral programme. Although in collaborative schemes the key feature is that a business supervisor is involved in the supervision and follow-up of the doctoral research, the academic supervisor remains the ultimate person responsible for leading and ensuring the successful completion of the doctoral research project and for the scientific soundness and quality of the research conducted.

Building and maintaining trustful relationships among all stakeholders is essential to ensure the success of a collaborative doctoral scheme. Understanding each partner's needs and objectives, establishing clear and realistic expectations and ensuring regular contact between the parties is vital to build trust and to develop long-term university-business partnerships. Previous university-business research collaborations among the partners is a prime factor naturally facilitating the establishment of collaborative doctoral schemes. Planning the activities of the doctoral project well in advance and ensuring that they all make sense within the framework of the research project is a determining factor in the quality and functioning of the partnership. Involving all stakeholders in the different lifecycle stages of the scheme is also needed to ensure its success. Examples cited of this include when a company suggests a research topic, it is important to assess if it contains enough scientific challenges for proper doctoral research content; that safeguard mechanisms need to be agreed on by partners regarding the appropriate time and placement commitments, in order to ensure the doctoral programme stays on schedule.

On employability, evidence from the study shows that universities, companies and doctoral candidates all considered that doctorate holders who graduated from a collaborative scheme had more job opportunities in the non-academic sector than doctorate holders who graduated from a traditional programme. The ability to be "bilingual", bridging the academic and business sectors, and the development of transferable skills, were identified as the main reasons accounting for the enhanced employment prospects of doctorate holders in the non-academic sector.

The project showed also that teamwork is a skill highly appreciated by companies, but noted that in doctoral education there is a limit to this concept: the research outcomes not only have to be original but also have to be originated by the doctoral candidate him/herself. Companies also indicated the need for a highly specialised workforce, often with interdisciplinary expertise, to cope with the new challenges they face in their particular markets. This aspect has increasingly influenced the recruitment of doctoral candidates in the industry/business sector.

It is hoped that these project findings can be a valuable source of good practices for all relevant stakeholders and that they can spark the interest of the academic and the business communities to both engage in, and further consolidate research collaborations in doctoral education.

1 THE DOC-CAREERS II PROJECT: CONTEXT AND METHODOLOGY

1.1 INTRODUCTION

EUA's work with its university membership, both in relation to its involvement in the Bologna Process and the development of its research and innovation activities, has given considerable priority to the enhancement and promotion of good practices in doctoral education. EUA was centrally involved in bringing empirical evidence obtained from its membership into the "Third Cycle" (focusing on doctoral education) of the Bologna Process, which culminated in the articulation of the "Salzburg Principles"[4] as core foundations for doctoral education.

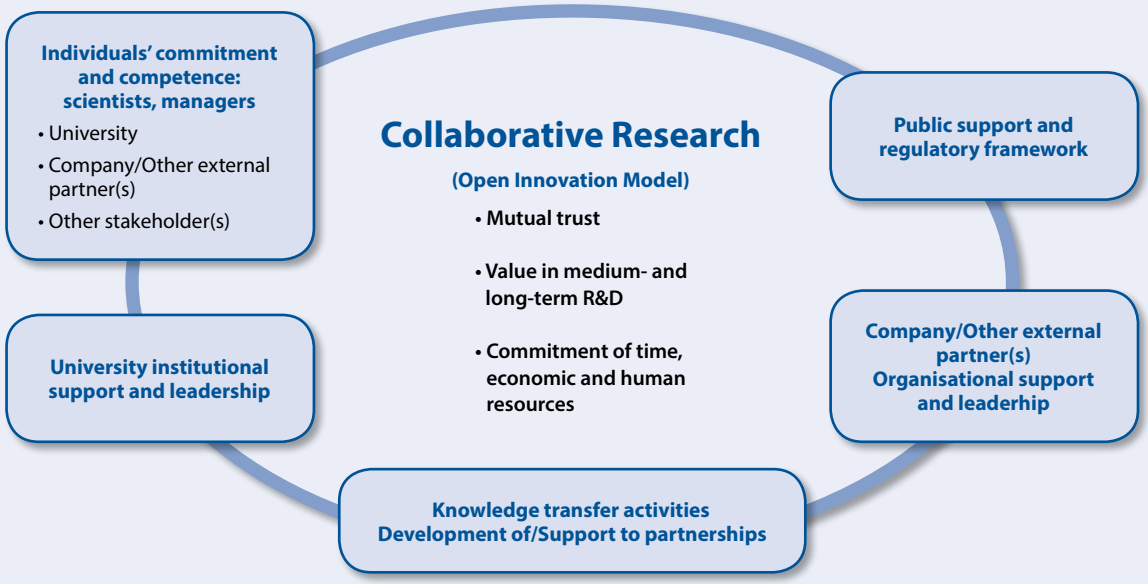
The "Salzburg Principles" have been taken up in European policy development particularly with respect to European Commission policy initiatives on enhancing European research careers and the wider framework of the development of the European Research Area (ERA). In particular, the key issue of professional skills requirements for employability of doctorate holders in the non-academic sector, including fostering greater intersectoral mobility, came to the forefront as a European policy concern. EUA as the main stakeholder for Europe's universities actively engaged in this policy debate and argued the case for future policy development to be based upon empirical evidence from good practices. This was felt to be necessary because the policy debate on this key issue was too often characterised by anecdotal opinions and statements which can be best summarised as "the basic problem is that universities have no contact with industry and business". These blunt assertions needed to be challenged by facts.

As a consequence, EUA responded successfully to a European Commission FP6 call for proposals which resulted in the first DOC-CAREERS project being conducted over the period of 2006-2009. The findings of this project were widely disseminated through the pioneering EUA report on "Collaborative Doctoral Education: University-Industry Partnership for Enhancing Knowledge Exchange".[5] The study identified the core components required for collaborative doctoral education drawn from current good practices involving universities, businesses and other external partners and which, crucially, were embedded in the framework of the requirements for successful collaborative research itself (Figure 1).

[4] Available at: www.eua.be/Libraries/Publications_homepage_list/Salzburg_II_Recommendations.sflb.ashx

[5] Borrell-Damian, L., 2009, *Collaborative Doctoral Education. University-Industry Partnerships for Enhancing Knowledge Exchange. DOC-CAREERS Project* (Brussels, EUA). www.eua.be

Figure 1. Components of collaborative doctoral education



Source: DOC-CAREERS project

Subsequently, EUA won a further contract from the European Commission to explore specifically the "regional dimension" of collaborative doctoral education by disseminating and further testing the core components identified in DOC-CAREERS across the European regions. This work was conducted from 2010 through 2012 and became known as the DOC-CAREERS II project and involved many university-business collaborations with the main actors directly involved as participants. The empirical findings from this second study have fed into the policy dialogue between the EUA, the European Commission and other European institutions on the shape and content of HORIZON 2020 (e.g. Marie Skłodowska-Curie Actions) and the European Structural and Investment Funds, in particular with respect to the design and implementation of the "Smart Specialisation Strategy" which has the potential to help universities play a comprehensive role in the economic and social development of European regions. However, until now, the results of the DOC-CAREERS II project had not been published, hence the present report.

EUA regards this report's findings as also being highly relevant to its current work with other European stakeholders engaged with the European Commission on the further development of the ERA. This work is being conducted through a "Memorandum of Understanding"[6] that addresses the main "bottlenecks and barriers" inhibiting ERA's implementation (specifically relevant to this project are those listed under the category of actions on "doctoral training, careers, mobility"). As indicated above, the report findings need to be read also in the context of EUA's continuing work on collaborative research between universities, businesses and other external partners and, in particular, its recent publication of the EUIMA project report "University-Business Collaborative Research: Goals, Outcomes and New Assessment Tools"[7] and the new interactive web-based "Assessment Tool for University-Business Collaborative Research Partnerships (U-B Tool)".[8]

[6] Available at: www.eua.be/Libraries/Research/MemorandumEUA.sflb.ashx
[7] Borrell-Damian, L., Morais, R., & Smith, J. H., 2014, *University-Business Collaborative Research: Goals, Outcomes and New Assessment Tools. The EUIMA Collaborative Research Project Report* (Brussels, EUA). www.eua.be
[8] Available at: http://ubtool.eua.be

1.2 APPROACH AND METHODOLOGY

The methodology used in the project is built on the experience and outcomes of the first DOC-CAREERS project. As in DOC-CAREERS, the main tools used to collect information on collaborative doctoral education in DOC-CAREERS II included case studies gathered through structured questionnaires and presentations in the workshops. However, a major change in focus from the previous DOC-CAREERS project was the selection and foci of the case studies.

In DOC-CAREERS, the case studies had been identified through targeting several sectors – university, company, doctoral candidates or other higher education and research organisations – and their selection processes were independent but based upon a minimum set of common criteria. In DOC-CAREERS II, the case studies were selected specifically through targeting the university sector, in order to study how universities work with their external partners. Institutions were asked to liaise with their doctoral candidates and their external partners who were involved in specific collaborative doctoral projects or programmes in order to collect "full stories" – from the inception of the doctoral thesis to employability of the doctorate holder – and to include the perspectives of all stakeholders involved in the partnership (university, external partner, doctoral candidate). In addition, the areas of focus in the case studies reflected the main trends and cross-cutting issues identified in DOC-CAREERS, but a greater emphasis was put on the regional dimension of the university-business collaborations.

The "full stories" mentioned above were collected through presentations in the workshops and/or through specific questionnaires addressed to each of the three stakeholders contributing to the case study: university (professor acting as doctoral supervisor), external partner and doctoral candidate. This meant that a university which involved one of their external partners and one or more doctoral candidates enrolled in a collaborative doctoral programme filled in a university questionnaire, coordinated the collection of the doctoral candidates' questionnaire responses, and provided EUA with the name and contact details of the representative in the external partner organisation to be interviewed by EUA using the external partner questionnaire. In the case of workshops, the "full stories" approach meant that case studies were presented in the form of a "double-act" (e.g. university-external partner; university-doctoral candidate) or a "triple-act" (university-external partner-doctoral candidate).

The selection of case studies was primarily based on evidence of long-term partnerships between the university and external partners, namely collaborative doctoral programmes. In addition, case studies were also selected taking into account other factors such as evidence of regional interest in building a highly skilled workforce for innovation and economic growth, and achieving a balanced geographical distribution of case studies from across Europe.

It is important to note that the workshops and questionnaires were viewed as two complementary, and equally important, approaches to collect information on collaborative doctoral schemes. While workshops focused on the presentation of the main characteristics and trends of collaborative schemes and fostered the dialogue among universities, companies and doctoral candidates, the questionnaires provided more structured input on the experience of the different stakeholders and reinforced the robustness of the project's outcomes.

During the DOC-CAREERS II project, five workshops[9] were held across Europe:

- Workshop 1: Dublin Institute of Technology (DIT), Dublin, Ireland: 21 September 2010
- Workshop 2: École Polytechnique Fédérale de Lausanne (EPFL), Lausanne, Switzerland: 10 December 2010

[9] All the presentations of the DOC-CAREERS II workshops are available on the following webpage: http://www.eua.be/eua-work-and-policy-area/research-and-innovation/doctoral-education/doc-careers-ii.aspx

- Workshop 3: Kaunas University of Technology (KUT), Kaunas, Lithuania: 5 April 2011
- Workshop 4: Norwegian University of Science and Technology (NTNU), Trondheim, Norway: 7 June 2011
- Workshop 5: University of Camerino (UNICAM), Camerino, Italy: 11 October 2011

As a key dissemination activity of the project, a final conference was organised in Brussels on 30-31 January 2012 to inform the European policy community about the outcomes of the project. This conference showcased case studies from the workshops' host institutions. The presentations reflected the variety of top-down and bottom-up collaborative models, which were put in the context of current European policy development through a debate with high-level representatives of the European Commission Directorates-General Research (DG Research, Skills Unit) and Education and Culture (DG EAC, Marie Curie Actions Unit).

In addition to the case studies presented in the workshops, 13 universities (representing 18 doctoral programmes), 21 doctoral candidates and 14 companies/external partners working together in collaborative doctoral projects contributed with structured case studies through questionnaires specifically designed for each target group. Overall, universities, companies and doctoral candidates from 13 European countries contributed to the DOC-CAREERS II project (for the complete list of participants in the project, see Annex 1).

The areas addressed in both the workshops and questionnaires covered a wide range of topics, ranging from the establishment of the doctoral scheme, its management (admission, monitoring, supervision) and sustainability, to the employability of doctorate holders. More specifically, the main topics discussed in the workshops and questionnaires included:

- How universities and external partners set mutually beneficial objectives for their collaboration, creating a favourable environment for a doctoral candidate to develop his/her skills as a researcher;
- How the doctoral process was conducted and monitored by both parties;
- How universities and companies selected doctoral candidates and how companies recruited doctorate holders;
- How intellectual property rights were managed in doctoral education in cooperation with the industry and other external partners;
- Policy contexts and their characteristics, which may foster or hinder collaborative research.

The case studies presented in the workshops and through questionnaires included examples from different fields of knowledge and business sectors: Science, Engineering and Technology (SET), Biotechnology, Medical and Life Sciences (BML) and Economic, Social Sciences and Humanities (ESSH).

1.2.1 WORKSHOPS: PROGRAMME STRUCTURE AND KEY CHARACTERISTICS

A unique characteristic of the DOC-CAREERS II workshops was that the universities presenting their case studies reflected the "full story" approach by being accompanied by their business/external partners and/or the doctoral candidates enrolled in collaborative programmes. Thus, the presentations of case studies had the format of "double-acts" (university-doctoral candidate or university-business/external partner) or "triple-acts" (university-doctoral candidate-business/external partner).

Another particular characteristic of the DOC-CAREERS II workshops was their structure, which was carefully tested and reviewed to achieve maximum outcomes from one-day activities. It included high-level expert

sessions (6-7 hours), allowing extensive time for in-depth dialogue among invited collaboration partners, followed by an open session (1.5 hours) focusing on dissemination and communication to a broad audience including university staff, students and prominent representatives of the region, who were interested in issues pertaining to collaborations in doctoral education.

Overall, the five DOC-CAREERS II workshops displayed common features reflecting a holistic approach to collaborative doctoral education. The key features can be summarised as follows:

(a) Regional approach: the workshops focused on the local/regional dimension in which the university operated, by identifying case studies illustrating practices in the region and by contextualising this activity in the overall role of university doctoral education in the economic and social development plans for the region. EUA allowed each host university to define the remit of their "region". This proved to be very useful because, across the five workshops, several different regional concepts were shown through the doctoral collaboration:

- Dublin Institute of Technology (DIT): Local Dublin and Ireland
- École Polytechnique Fédérale de Lausanne (EPFL): Local Lausanne with a high component of worldwide outreach
- Kaunas University of Technology (KUT): Local Kaunas and Lithuania
- Norwegian University of Science and Technology (NTNU): Local Trondheim and Norway
- University of Camerino (UNICAM): Marche region of Italy

(b) European scope: the workshop included at least one external case study as a counter-example to the locally provided case studies. This was used as a tool for reflection on common and distinctive elements from a regional perspective. EUA ensured that the expert workshop audiences had a minimum proportion of non-national/non-regional participants (at least 15%) to foster dialogue at both regional and European levels:

- Dublin Institute of Technology (DIT): 58% region/country Ireland – 42% non-Irish
- École Polytechnique Fédérale de Lausanne (EPFL): 40% region/country Switzerland – 60% non-Swiss
- Kaunas University of Technology (KUT): 60% region/country Lithuania – 40% non-Lithuanians
- Norwegian University of Science and Technology (NTNU): 50% region/country Norway – 50% non-Norwegians
- University of Camerino (UNICAM): 60% region/country Italy – 40% non-Italians

(c) Intersectorial/multi-stakeholder: as indicated before, the workshops involved the three main stakeholders in the collaborative doctoral project – university supervisor, doctoral candidate, company supervisor – in the form of "double-acts" or "triple-acts". The three voices were heard in the workshops on an equal basis. In addition, the broad range of sector representatives invited to the expert sessions included higher education policy makers, research and technology organisations, university networks, professional bodies, heads of doctoral schools, health authorities and regional policy authorities:

- Dublin Institute of Technology (DIT): 67% university sector, 11% industry sector, 22% others in the higher education and research sector

- École Polytechnique Fédérale de Lausanne (EPFL): 58% university sector, 18% industry sector, 24% others in the higher education and research sector
- Kaunas University of Technology (KUT): 65% university sector, 5% industry sector, 30% others in the higher education and research sector
- Norwegian University of Science and Technology (NTNU): 59% university sector, 16% industry sector, 24% others in the higher education and research sector
- University of Camerino (UNICAM): 60% university sector, 16% industry sector, 24% others in the higher education and research sector

(d) Multidisciplinary coverage: the workshops and case studies covered many different areas within the broad fields of Science, Engineering and Technology (SET), Biotechnology, Medical and Life Sciences (BML) and Economics, Social Sciences and Humanities (ESSH). Although there were more cases from the first two areas than from the third, ESSH-related case studies were presented in all the workshops. This proved to be valuable in contributing to the enrichment of dialogue among professionals from different disciplines:

- Dublin Institute of Technology (DIT): environmental health, nutrition, engineering, migration and communication, bioprocesses, creative arts and media
- École Polytechnique Fédérale de Lausanne (EPFL): engineering, healthcare, materials manufacturing and consulting
- Kaunas University of Technology (KUT): energy, health, engineering, business and management
- Norwegian University of Science and Technology (NTNU): international project management, petroleum geophysics, renewable electrical energy, perceptual and brain sciences
- University of Camerino (UNICAM): engineering, materials, health (malaria) and security

(e) High-level and experienced practitioners as participants: the workshops always involved the active presence of the rector of the host university (Dublin Institute of Technology: Prof. Brian Norton; École Polytechnique Fédérale de Lausanne: Prof. Patrik Aebischer; Kaunas University of Technology: Prof. Eugenijus Uspuras; Norwegian University of Science and Technology: Prof. Torbjørn Digernes; University of Camerino: Prof. Fulvio Esposito) and the presence of vice-rectors and directors of the doctoral school, one or more high-level authority from the region/country, and top representatives from major stakeholder networks in the field (Dr Leopold Demiddeleer, EIRMA; Prof. Jean Chambaz, Chair of EUA-CDE; Dr Janet Metcalfe, Vitae).

Importantly, the host organisations designated high-level and competent individuals to organise the workshops. All of them held leadership positions in their respective institutions' rector offices: Prof. Mary McNamara (Dublin Institute of Technology); Dr Verity Elston (École Polytechnique Fédérale de Lausanne); Vice-Rector Dr Rymantas Kazys (Kaunas University of Technology); Dr Raghild Lofthus (Norwegian University of Science and Technology); Prof. Cristina Miceli (University of Camerino). Their dedication and efforts in selecting the collaboration case studies and, importantly, their representatives were key to the success of the workshops. High-level individuals from companies also took part in the workshops (e.g. CEOs and heads of the R&D departments).

(f) Optimal number of participants with extensive time for discussions focusing on open European dialogue: Workshop participants were provided adequate time which allowed for focused and in-depth discussions with the active participation of the audience, and this created an environment where people felt confident to speak freely.

- Dublin Institute of Technology (DIT): 45 experts from 11 European countries
- École Polytechnique Fédérale de Lausanne (EPFL): 33 experts from nine European countries
- Kaunas University of Technology (KUT): 40 experts from nine European countries
- Norwegian University of Science and Technology (NTNU): 50 experts from nine European countries
- University of Camerino (UNICAM): 55 experts from 10 European countries

(g) Open dissemination: the widening of the dialogue during the open session raised awareness of collaborative doctoral education to an audience composed mainly of university students and professors, but also involving higher education policy representatives, representatives from industry and other professional bodies. It also broadened the scope of the workshop with contributions by high-level speakers that highlighted the added value that doctorates bring to regional development and company development when organisations put value on innovation through R&D (e.g. Prof. Patrick Aebischer, President, École Polytechnique Fédérale de Lausanne and Dr Nerija Putinaite, Vice-Minister of Education and Science, Lithuania).

(h) Common focus: The three stakeholder questionnaires (described below) were used as the common framework to develop the main subjects for discussion in each workshop.

1.2.2 QUESTIONNAIRES: KEY CHARACTERISTICS

The questionnaires were prepared with a view to collect structured input from participants and they were used as a framework to prepare the key questions for discussion in the workshops and final conference. Three questionnaires were prepared including specific questions to each of the three stakeholders: university professors acting as doctoral supervisors, doctoral candidates and companies or other external partners. They were developed based on the questionnaires from DOC-CAREERS, which were updated according to the outcomes of the project. The main characteristics of the DOC-CAREERS II questionnaires are described below.

- **Questionnaire for universities on doctoral programmes in cooperation with external partners:** a total of 13 universities contributed with case studies, covering 18 doctoral programmes. The questionnaire for universities was composed of 45 questions structured in six parts, namely: i) institutional data; ii) general data of the doctoral scheme; iii) employment outcomes of the doctoral scheme; iv) the university-business partnership: the process of setting up the doctoral scheme; v) the university-business partnership: the main characteristics of the doctoral scheme; vi) impact of the doctoral scheme and lessons learned.

- **Questionnaire for external partners participating in doctoral collaborations with universities:** a total of 14 companies agreed to take part in this consultation. These companies were identified by the participant universities (as one of their external research partners) and by EIRMA, the European Industrial Research Management Association (one of the organisations in the Steering Committee of DOC-CAREERS II). The consultation took the form of site visits or 30-minute phone interviews completing the business/external partner questionnaire which was composed of 48 questions structured in three parts: i) general information; ii) experience with specific doctoral training schemes; iii) general lessons learned.

- **Questionnaire for doctoral candidates enrolled in doctoral programmes in cooperation with external partners:** a total of 21 doctoral candidates/holders with experience in collaborative doctorates responded to the questionnaire. They were enrolled or had been recently enrolled as doctoral candidates in a collaborative doctoral project in one of the 13 universities that contributed to the project. The questionnaire addressed to doctoral candidates was composed of 29 questions structured in three parts: i) researcher data; ii) general data of the doctoral scheme; iii) impact of the doctoral scheme.

1.2.3 DEFINITIONS

The definition of collaborative doctoral projects in DOC-CAREERS[10] was validated by the additional case studies in DOC-CAREERS II and therefore the same definition was adopted to identify collaborative doctoral projects:

Collaborative doctoral projects: "These are doctoral theses carried out with interaction between a university, a company and a doctoral 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."[10]

The analysis of the case studies and workshop outcomes[11] focused on the main trends and cross-cutting issues in the collaborative doctoral programmes presented by universities, companies and doctoral candidates. In this report, the authors have sought to bring to the fore the main aspects identified and shared by the stakeholders, showing their commonalities, but also their distinctive views on the process of collaborative doctoral education, as these elements can be potentially applicable to a wider group of universities, and to external partners interested in developing partnerships. The aim is, therefore, to share the main lessons and good practices that universities, companies and doctoral candidates have learned throughout their experience in developing and undertaking collaborations, particularly collaborative doctoral projects.[12]

A methodological note is necessary here concerning the nature of the figures presented throughout the report. These figures reflect the data provided by universities, companies and doctoral candidates in the case study questionnaires. We caution the reader to bear in mind that the graphs are presented to better illustrate the results of the project and to complement the information presented in the text, but the quantitative results cannot be generalised to other collaborative doctoral schemes or to collaborative doctoral education in general.

Finally, it should also be noted that throughout the text the terms external partner, business, company and industry are used interchangeably, which reflects the diversity of the terminology used by the practitioners who provided their case studies. These are used as general terms to refer to the collaboration between a university and an external partner, which can be either a for-profit entity (e.g. large companies, SMEs) or a not-for-profit organisation (e.g. research institutes, NGOs, public authorities).

[10] Borrell-Damian, L., 2009, *Collaborative Doctoral Education. University-Industry Partnerships for Enhancing Knowledge Exchange. DOC-CAREERS Project* (Brussels, EUA). www.eua.be

[11] The DOC-CAREERS II project ran between 2009 and 2012. Naturally, most, if not all, of the doctoral schemes described in this report have evolved since the project came to its end in 2012.

[12] For more information on the specific case studies included in DOC-CAREERS II see Annex 1.

2 DEVELOPING AND UNDERTAKING COLLABORATIVE DOCTORAL EDUCATION

The main components of collaborative doctoral programmes identified in the first DOC-CAREERS project were validated in DOC-CAREERS II. These components include: strategic level of engagement in the organisation (university and business); roles of industrial partners; selection of the doctoral research topic; additional admission requirements for doctoral candidates; formal agreements and general conditions; legal status of the doctoral candidate; and supervisory scheme. The results of DOC-CAREERS II support the importance of these components to characterise collaborative doctoral programmes and extend the findings of DOC-CAREERS by providing a more comprehensive and integrated perspective on the views of universities, companies and doctoral candidates engaged in collaborative doctoral schemes.

The main outcomes of the DOC-CAREERS II project are presented below. They are organised in five sections covering the whole breadth of relevant aspects involved in setting up and taking forward collaborative doctoral education. The outcomes were drawn from case study evidence provided by universities, their external partners and doctoral candidates and from the contributions of all stakeholders in the workshops.

2.1 CONTEXTUAL FACTORS AND MOTIVATIONS TO ENGAGE IN COLLABORATIVE DOCTORAL EDUCATION

The regional context in which universities and companies are embedded, the policy frameworks in place and the specific characteristics of the local and regional environment, are all factors that can facilitate the development and consolidation of university-business partnerships. Indeed, in some of the university-business partnerships considered in the DOC-CAREERS II project, national legislation or regional strategic plans were important catalysts for the development of closer ties between the university and the industry sector (e.g. University of Ferrara, Bangor University, Kaunas University of Technology, Intel Ireland). Geographical proximity between universities and their external partners was clearly a key factor indicated by universities in facilitating the development of partnerships.

In addition, the increasing degree of complexity, the fast changing pace of technological, economic and social challenges faced by businesses and universities and the need to create innovative solutions required

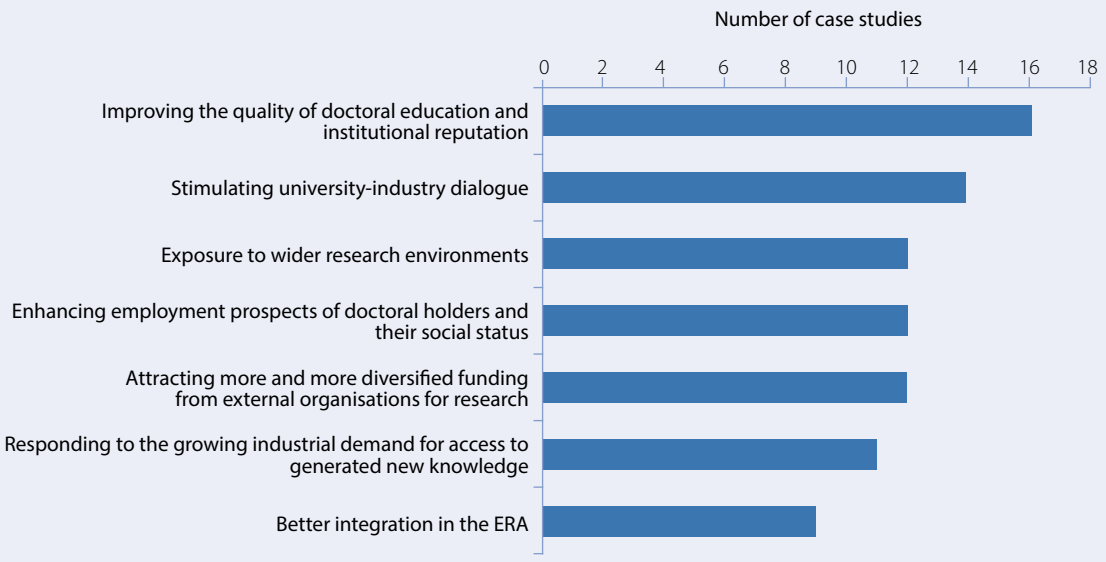
knowledge and skills that cross-cut functional areas of knowledge and sectorial activity. This naturally called for a closer relationship between universities and companies.

2.1.1 MOTIVATIONS FOR UNIVERSITIES, COMPANIES AND DOCTORAL CANDIDATES TO ENGAGE IN COLLABORATIVE DOCTORAL EDUCATION

Advancing their competitive advantage and fostering innovation were the main incentives for both universities and companies in strengthening their cooperative relations. For universities, this was related to furthering their relative position in the higher education landscape, as their mission and core activities in teaching and research were increasingly related to innovation. Indeed, research and innovation activities were perceived by universities as essential pillars of their development, allowing them to better tackle societal challenges and to contribute to regional and national development. Interacting with industry partners, namely via the establishment of collaborative doctoral schemes, was therefore considered as an important strategic activity for universities, as it pushed forward the development of interdisciplinary training, provided innovative solutions for complex problems responding to industry needs and supplied a highly skilled workforce for companies. Advancing research, namely through cooperation with the business sector, also gave universities more visibility, nationally and internationally, and allowed them access to a wider pool of funding sources (e.g., industry partners, international competitive funding). Cooperation with the business sector also supported universities in strengthening the perceived value of research, namely to companies and other external partners.

More specific reasons indicated by universities to engage in collaborative doctoral schemes included a variety of motivations such as improving the quality of doctoral education and the reputation of the university, stimulating university-business dialogue and enhancing the employment prospects of doctorate holders (see Figure 2).

Figure 2. Motivations and incentives of universities to plan the collaborative doctoral scheme



Notes: multiple-choice question. Number of responses: 17/21.
Source: DOC-CAREERS II case studies - doctoral candidates

For companies, increasing competitiveness and advancing their position in the market was considered as the main incentive to engage in university-business cooperation and, more specifically, in collaborative doctoral schemes. Some companies also highlighted that establishing long-term partnerships with universities was perceived as an integral part of the firm's strategy in order to remain competitive and that it allowed the firm to access additional funding sources. Developing and strengthening cooperation with universities allowed companies to access and further develop cutting-edge scientific and technical knowledge to tackle industrial challenges. Companies also indicated that collaborative doctoral schemes contributed to the quality of the firm's recruitment, as highly skilled individuals became readily available to the recruitment pool of companies. This therefore allowed companies to enhance their employees' skill profiles and competencies and had a positive effect in increasing the firm's competitiveness (Table 1).

Table 1: Companies' motivations and incentives to engage in collaborative doctoral education

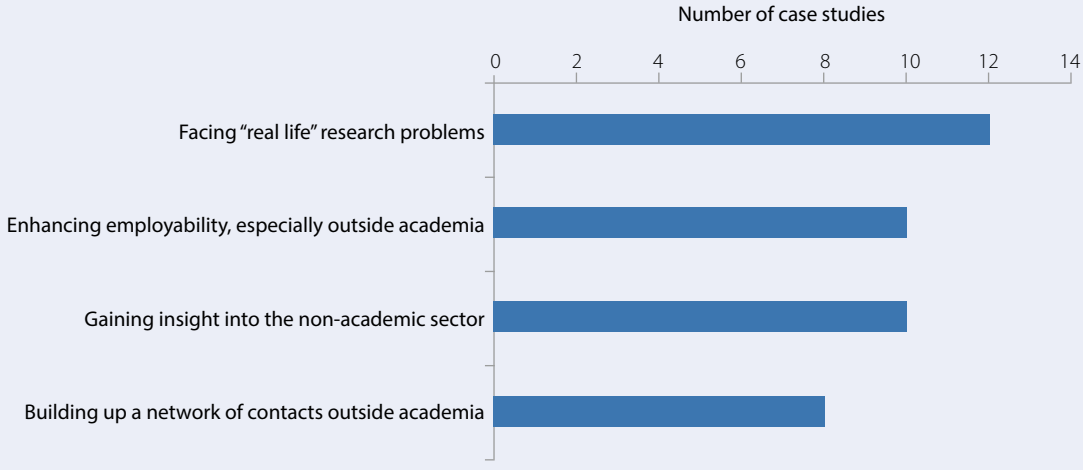
- Increasing competitiveness
- Viewing university-business collaboration as part of the company's strategic plans
- Broadening research funding sources
- Accessing cutting-edge research and technological developments
- Tackling industrial challenges
- Enhancing the quality of the recruitment pool available to the company

Source: DOC-CAREERS II case studies – companies

Companies also highlighted that collaborative doctoral training was beneficial for all knowledge-based companies, irrespective of their size, i.e., whether they were large companies or Small and Medium Enterprises (SMEs). In the same vein, collaborative doctoral schemes were also perceived as beneficial for the public sector, as it allowed public authorities to access high-level knowledge and skills, which may be typically difficult to find in-house.

For doctoral candidates, the main motivation to enrol in a collaborative doctoral scheme was the opportunity to develop research more applicable to "real life" problems, followed by the chance to increase their employment prospects, particularly in the non-academic sector (see Figure 3). Gaining a better insight into the non-academic sector was also frequently reported as a reason to enrol in a collaborative scheme.

Figure 3. Motivations for doctoral candidates to enrol in the collaborative doctoral scheme



Notes: multiple-choice question. Number of responses: 16/18.
Source: DOC-CAREERS II case studies – universities

Some doctoral candidates indicated additional motivations to enrol in the collaborative scheme. These mainly related to:

- Advantages of the collaborative scheme over traditional doctoral programmes, such as establishing contact with the company or gaining broader knowledge and experience;
- Personal motivations, such as interest in the research topic and wish to gain an academic insight into that topic.

For doctoral candidates who were already employed prior to enrolling in the scheme, the main motivation was gaining an academic perspective on the research topic under study and building a network of contacts in the university.

The views of universities – Examples from case studies:

Dublin Institute of Technology: "*Close engagement locally and globally with society and the economy, and collaborative links with a range of world-class companies and academic institutions internationally are essential components in everything DIT does.*"

University of Ferrara: *"The doctoral scheme is pursued within the region Emilia Romagna and in close proximity of other main productive regions such as Lombardia and Veneto. There are close relations between the companies based in these regions and our university (…) Thus, research programmes are calibrated in relation to the possible need of external recipients of the research and of the doctorates."*

Kaunas University of Technology: "*(…) a university which is a partner of industry, business, NGOs, and the society.*"

University of Camerino – UNICAM Chemical: *"GoldenPLast feels the responsibility to remain competitive and keep growing. It is no longer possible to much count on suppliers and competitors to obtain information, but it is absolutely necessary to acquire proprietary scientific knowledge and professional wisdom. As a consequence, GoldenPlast has felt the need to draw the attention of UNICAM to its activities and decided to start a cooperation based on a doctorate."*

The views of companies – Examples from case studies:

Intel Ireland: *"Ireland's strategy in the engineering field – this already doubled the number of PhDs and it encourages us to sponsor PhDs (…). We would like to develop a Strategy Research Programme – partnerships with the universities are the best for that (…). Influence on the research that takes place in the university – partnership and collaboration."*

Solvay Belgium: *"Access to leading edge expertise in new fields."*

Fasrund Aluminium Casting: *"(…) new techniques, which leads to economic benefits."*

Otivio: *"Access to higher people in university also access to laboratories, knowhow, experience."*

The views of doctoral candidates – Examples from case studies:

Doctoral candidate – University College London (UCL): *"[I] believed that this doctoral programme would significantly improve my future employment options because the nature of the programme is to collaborate with industry."*

Doctoral candidate – Ghent University: *"I was already employed. This scheme helps me to build up a network in university and gain more insight into the problems we are facing at my company."*

Doctoral candidate – Norwegian University of Science and Technology (NTNU): *"[It was an] opportunity to finance a theme that I was interested in to gain more academic insight."*

2.2 BENEFITS OF COLLABORATIVE DOCTORAL EDUCATION

Universities, businesses and doctoral candidates considered that engaging in collaborative doctoral education brought about a variety of benefits to all stakeholders.

Universities and companies highlighted the role of collaborative doctoral schemes in strengthening university-business partnerships and in promoting long-term collaborations. More specifically, universities considered that some of the major benefits of collaborative doctoral education entailed training a highly skilled workforce and strengthening industry interest and engagement in university research. Institutions also mentioned the importance of increasing awareness of the technical challenges that companies face, promoting innovation and contributing to sustainable funding for research (see Figure 4). In addition, universities indicated as important outcomes of collaborative doctoral education the wider applicability of research results and the opportunity to change perceptions about university-business cooperation.

Figure 4. Benefits of collaborative doctoral education for universities

Notes: multiple-choice question. Number of responses: 16/18.
Source: DOC-CAREERS II case studies – universities

Companies, on the other hand, emphasised that collaborative doctoral education is an important tool for strengthening several aspects important to furthering competitive advantage, such as upskilling the workforce, developing new products, and supporting the long-term development and growth of the company (Table 2).

Table 2: Benefits of collaborative doctoral education for companies
• Improving the skillset of the workforce
• Developing new and innovative products
• Supporting the long-term development of the company

Source: DOC-CAREERS II case studies – companies

Universities, companies and doctoral candidates also considered that collaborative doctoral education provided a variety of distinctive advantages when compared to traditional doctoral programmes. The three stakeholders agreed on the following advantages:

- **The capacity of the doctoral candidate to bridge and integrate both the university and the business sector mindset**

  This was identified as the major advantage of collaborative doctoral education by all the stakeholders involved in collaborative programmes. This aspect was perceived simultaneously as the main advantage and the main challenge in pursuing a collaborative doctoral degree. All stakeholders, especially the doctoral candidates, need to balance the different needs, demands and expectations of the university and the industry partner arising in the collaboration process. In order to do so, they are required to become "bilingual" in both sectors, that is, to understand and efficiently manage the requirements of the university and the business partner. In spite of being perceived as a challenging task, it is exactly this factor that underpins the perception that doctorate holders from a collaborative scheme are more employable in the non-academic sector than doctorate holders from traditional programmes (cf. Chapter 3). It is also important to note that collaborative doctoral degrees entail the same standards for scientific quality of the research conducted as a doctorate in a traditional programme. But the distinctive factor of the collaborative doctoral scheme is that doctorate holders should be able to develop their work both in the academic and in the business environment.

- **The possibility to work in interdisciplinary areas**

  Working in scientific and technical areas that extend beyond the doctoral candidate's area of expertise was perceived as one of the key advantages of collaborative doctoral schemes. Similarly, the involvement of doctoral candidates in applied research, the opportunity to undertake research projects relevant for both the academic and the industry partner, and gaining a broader perspective of the research topic considered, were also seen as relevant advantages. This involves a deeper understanding of the goals and challenges faced by both sectors, and the emergence of joint approaches that satisfy the different partners' needs and demands.

- **Developing transferable skills**

  Universities, businesses and doctoral candidates considered that undertaking a collaborative doctoral degree entails the development of important transferable skills relevant for both the university and the business sector. These transferable skills refer mainly to organisational and management skills, entrepreneurship, leadership and business skills, and communication skills (e.g. being able to present research outcomes to both an academic and a business-related audience). Career guidance provided by industry mentors, the development of a network of contacts in the university and the company and the possibility for doctoral candidates to attend training sessions organised by the company or to use

the firm's research infrastructure were also pointed out as distinctive advantages of the collaborative scheme.

The views of universities – Examples from case studies:

Norwegian University of Science and Technology (NTNU): *"One of the assumptions behind establishing such a scheme is that candidates in these projects will develop unique competences and skills and be "bilingual" in terms of understanding the "languages" of both academic and non-academic sectors."*

University of Perugia: *"This doctoral scheme allows [doctoral candidates] to work with colleagues and engineers, resulting in more interdisciplinary [knowledge]."*

Ingolstadt University of Applied Research: *"[Transferable skills include] excellent time management, being able to work in a team, being able to work under time pressure, being able to explain complex issues so that even a non-expert can understand it, applying theoretical [knowledge] to applied research problems."*

The views of companies – Examples from case studies:

Skretting: *"[Doctoral candidates] see real company issues and see how results are implemented. In addition to publication they also work on applied issues."*

Fasrund Aluminium Casting: *"It is easier to come to work in the industrial field later. They get company experiences, practical experiences and they get to know industrial solutions."*

The views of doctoral candidates – Examples from case studies:

Doctoral candidate – Umeå University: *"I have also learned to handle both academic and industrial issues and people."*

Doctoral candidate – Newcastle University: *"Wider appreciation of other fields and how these can be incorporated into my own research."*

2.3 THE COLLABORATIVE DOCTORAL SCHEME IN PRACTICE

The main areas that universities and companies need to consider when setting up and taking forward a collaborative doctoral scheme are presented in this section. Overall both the universities and businesses emphasised the importance of two aspects which were considered essential to develop and sustain a collaborative doctoral scheme: the existence of trustful relationships between the partners and an adequate skill profile of the individuals involved in setting up and taking forward the collaborative doctoral scheme.

Building and sustaining trustful relationships between the university and the business partner was considered as the single most important factor in ensuring the success of collaborative doctoral schemes.

Defining a common vision, having realistic expectations, and reaching a shared understanding of each party's objectives, priorities and constraints, were key elements identified as a prerequisite to build trustful relations and to guarantee a successful collaboration. In addition, ensuring that the main actors involved in establishing and taking forward the collaborative scheme have an adequate skill profile was also perceived as a key aspect for the success of the partnership. In this respect, universities and businesses emphasised, in particular, the fact that the company contact person should be aware of what research training entails, or should be a doctorate holder him/herself.

In addition to the two main elements described above, the stakeholders involved in the DOC-CAREERS II project identified several other aspects that universities and companies should consider when setting up and taking forward a collaborative doctoral scheme. These aspects are presented in the next two sub-sections.

2.3.1 SETTING UP THE COLLABORATIVE DOCTORAL SCHEME

The participant universities and companies have identified some important factors that all stakeholders should take into account to ensure the seamless development of the collaboration. Importantly, all stakeholders emphasised that collaborative doctoral schemes should be thoroughly planned and that this development stage should not be rushed, as it is a determining factor in the quality of the collaboration.

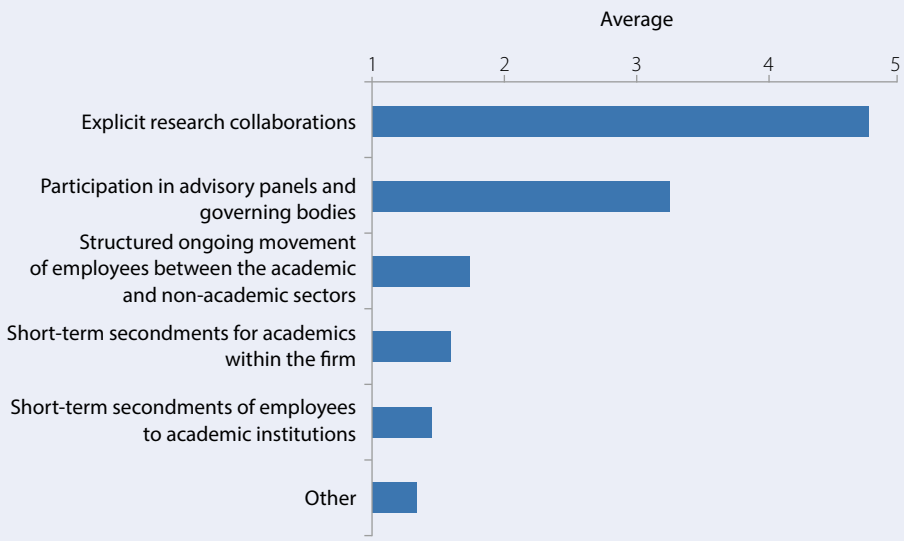
The main factors, identified by universities and companies that need to be taken into account while setting up the collaborative doctoral schemes were:

- The facilitating role of previous relationships between the partners for setting up the collaborative doctoral scheme;
- Establishing formal agreements between the partners;
- Dealing with Intellectual Property Rights (IPR);
- Defining the company's contribution to the collaborative doctoral scheme;
- Outlining the formal requirements for admission;
- Promoting the collaborative scheme.

2.3.1.1 THE FACILITATING ROLE OF PREVIOUS RELATIONSHIPS BETWEEN PARTNERS IN SETTING UP THE COLLABORATIVE DOCTORAL SCHEME

Several of the universities and companies involved in DOC-CAREERS II had already been working together before setting up the collaborative doctoral scheme. In some cases, collaboration had already been taking place on other initiatives on a long-term basis and was well-established. These relationships included different activities (see Figure 5), such as research collaborations, or the participation of the company's staff in academic activities (e.g. teaching, participating in governing boards, advisory roles). Secondments of researchers between the university and the company were perceived as a less important activity in fostering ongoing professional contacts between companies and universities. One company justified this perception because of the lack of incentives (e.g. career progression) for academics to work in firms.

Figure 5. Average importance of different activities in fostering ongoing professional relations between companies and universities

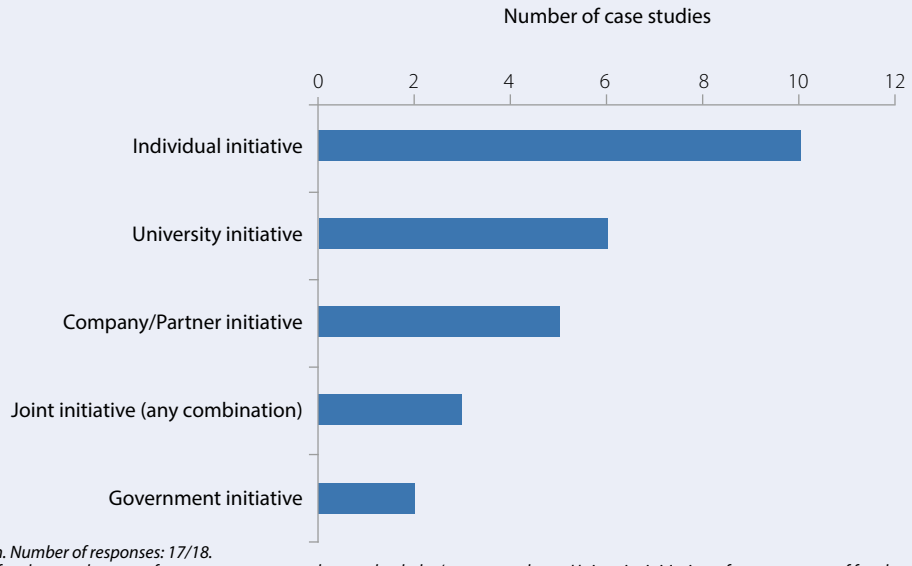


Notes: The scale ranges from 1 (low importance) to 5 (high importance). Number of responses: 11/14.
Source: DOC-CAREERS II case studies – companies

Other activities that helped the university and the business sector to maintain contact encompassed consultancy services provided by the university to the company, training provided by universities to respond to industrial needs (e.g. continuous professional development activities), and the establishment of spin-off companies. These previous university-business collaboration activities among the partners naturally facilitated the establishment of collaborative doctoral schemes.

The case studies revealed that initial contact between the university and the company was often established as a result of an individual initiative (see Figure 6). Universities also indicated that in many instances, individual professors started paving the way to the collaborative doctoral scheme and the institutional support of the university followed through in consolidating this contact. Collaboration between the partners was also frequently initiated by the university or by the company. In two case studies, Ghent University and University College London (UCL) BIOPROCESS, the initiative to establish the collaborative scheme originated at the governmental level and was taken up by a group of faculty members, individual professors and/or company staff.

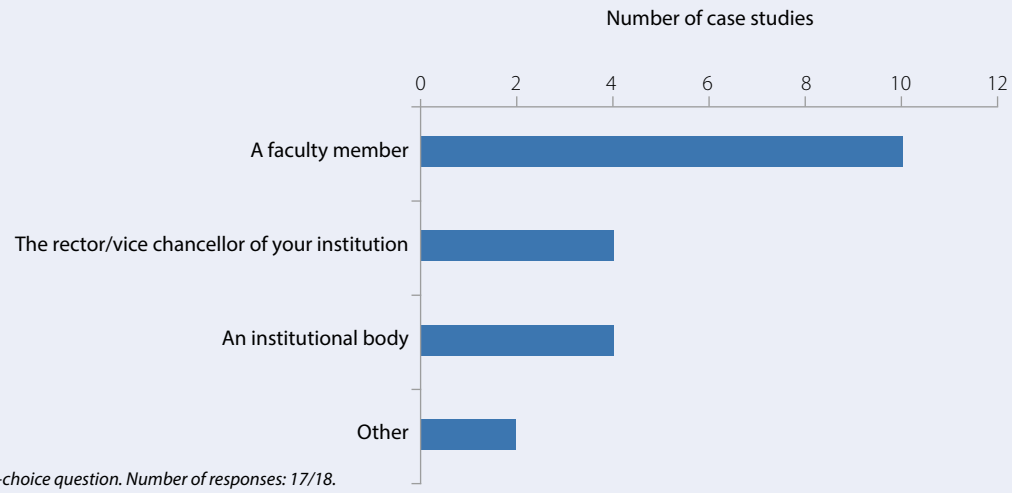
Figure 6. Stakeholder responsible for initiating the first contact between the partners to set up a collaborative doctoral scheme



Notes: multiple-choice question. Number of responses: 17/18.
Individual initiative refers to: a faculty member, a professor, a company employee, a bachelor/master graduate. University initiative refers to: a group of faculty members, a rector, vice-rector(s), a member of the administration, a knowledge transfer body, groups of universities. Company/partner initiative refers to: a CEO, company board, group of companies, RTD performer. Government initiative refers to: local, regional, national and/or EU government bodies and agencies.
Source: DOC-CAREERS II case studies – universities

The case studies also indicated that in about half of the instances a faculty member (e.g. head of department, senior professors, director or college dean) took the lead in setting up the collaborative scheme (see Figure 7).

Figure 7. Stakeholder responsible for leading the process of setting up the collaborative doctoral scheme



Notes: multiple-choice question. Number of responses: 17/18.
Source: DOC-CAREERS II case studies – universities

The rectors or vice chancellors and institutional bodies such as graduate schools or university offices were only responsible for leading the establishment of the collaborative doctoral scheme in about 20% of cases (four case studies).

The results of the case studies also indicated that, in some cases, the establishment of the collaborative scheme took about one year after the first contact between the university and the industry partner had been made. The main reasons identified for this timeframe were lengthy administrative and legal procedures.

The views of universities – Examples from case studies:

Dublin Institute of Technology (EHS scheme): *"There were long standing relationships with all partners going back over 30 years."*

University College London (UCL) – CoMPLEX: *"CoMPLEX was originally set up by UCL academics interested in mathematical and physical approaches to biology (…) and the value of cohort interdisciplinary doctoral training. All these initiatives have been strongly supported in the intervening years by UCL's Provosts and senior managers."*

The views of companies – Examples from case studies:

Schlumberger: *"Trustful relationships built with universities over the years."*

Intel Ireland: *"Already had good relationships with some universities, especially because we already hired PhDs and had our own PhD pipeline."*

Fasrund Aluminium Casting: *"[The] company realized the need for this technology, [and] they decided to take the initiative [in making the first contact with the university]."*

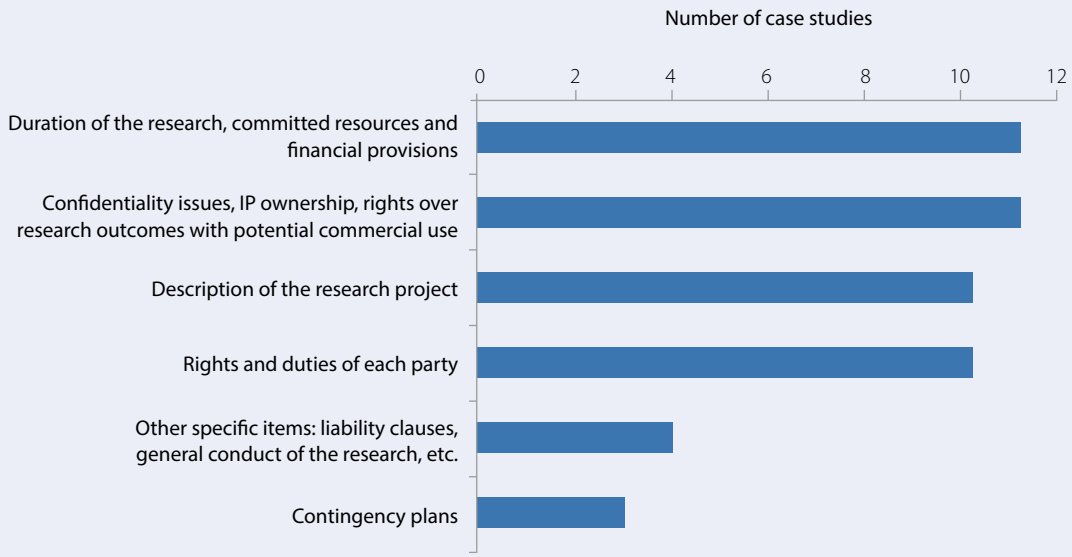
2.3.1.2 ESTABLISHING FORMAL AGREEMENTS BETWEEN THE PARTNERS

As part of the process of setting up the collaborative scheme, universities and companies strongly emphasised the importance of establishing formal agreements between the parties. These contracts should be comprehensive in scope, clearly stating the rights and obligations of all stakeholders – universities, companies and doctoral candidates.

In the majority of DOC-CAREERS II case studies, formal agreements between two (e.g. university-business; doctoral candidate-business) or the three parties (university-business-doctoral candidate) were undertaken. These contracts included a variety of areas (see Figure 8), but typically a combination of the following was found:

- General rules for collaboration: description of the research project, duration of joint research, decision-making procedures, rights and duties of each party;
- Financial provisions and allocation of resources;
- Confidentiality issues;
- Intellectual property ownership and rights over research outcomes with and/or without potential commercial use.

Figure 8. Areas covered in collaborative doctoral scheme agreements



Notes: multiple-choice question. Number of responses: 13/18.
Source: DOC-CAREERS II case studies – universities

The stakeholders further considered that these agreements should clearly state the parties' commitments beyond the research project work for the company, i.e. course requirements, teaching, presentations, meetings, as well as to define what happens if the doctoral process extends beyond the agreed funding, i.e. who would be financially responsible for the extra time and money needed for the doctoral candidate to complete his/her doctorate.

In many of the case studies, standard agreements were used, which could then be subject to negotiation depending on the characteristics of the specific research project and the needs of the university and the business partners. It was also considered beneficial to have a facility at the university that could provide standard contract models or expert advice during the negotiation of the partnership.

The views of universities – Examples from case studies:

Norwegian University of Science and Technology (NTNU): *"(…) it is important that universities and companies planning a cooperation ensure that all important aspects of the cooperation are discussed before the project commences. This is often more complicated and time consuming than expected, and the importance of this process should not be underestimated."*

Ghent University: *"For each project (…) a contract is negotiated and specific arrangements (that comply with the needs and demands of the university and the company, and fit within the general framework of the funding agency) are made."*

The views of companies – Examples from case studies:

GSK Biologicals: *"Yes, rules of collaboration, decision-making process (…) salary commitment by GSK."*

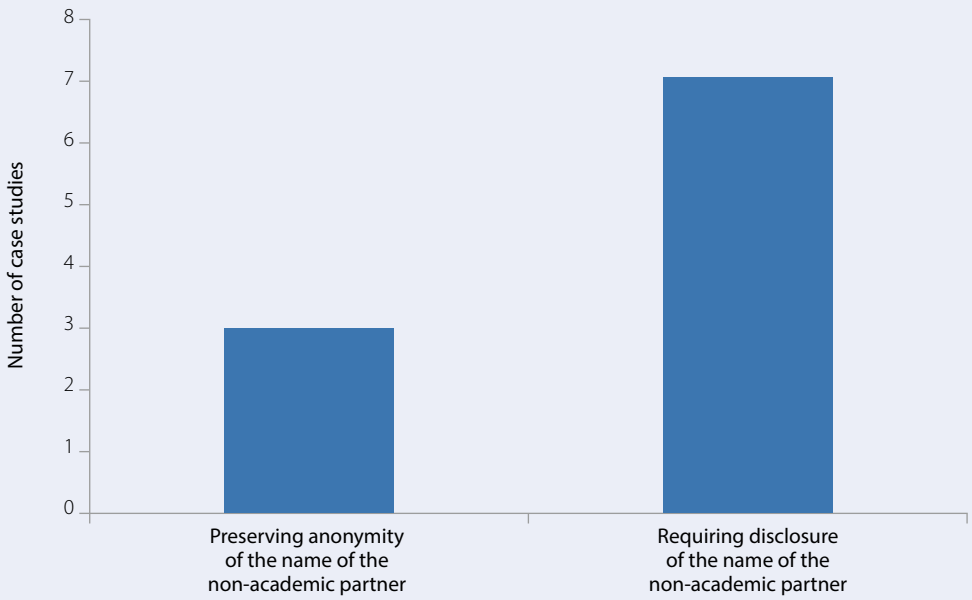
Umicore: *"[The agreements include] 1) a time commitment of 4 years 2) payment subject to reporting activities 3) dialogue dual reports/dual papers."*

2.3.1.3 DEALING WITH INTELLECTUAL PROPERTY RIGHTS

Intellectual Property Rights (IPR) and confidentiality/disclosure arrangements were considered as one of the most important areas that should be covered in the formal agreements of collaborative doctoral education. Universities and companies considered that IPR should be negotiated at the outset of the collaborative doctoral scheme, with a view to balance the partners' interests with respect to publication and potential commercial application. It was particularly emphasised that, in the context of a collaborative doctoral scheme, the right of the doctoral candidate to publish outcomes of his/her research should be ensured, in order to guarantee progress of the doctoral process. This should, preferably, be established before the start of the collaboration and the first research results.

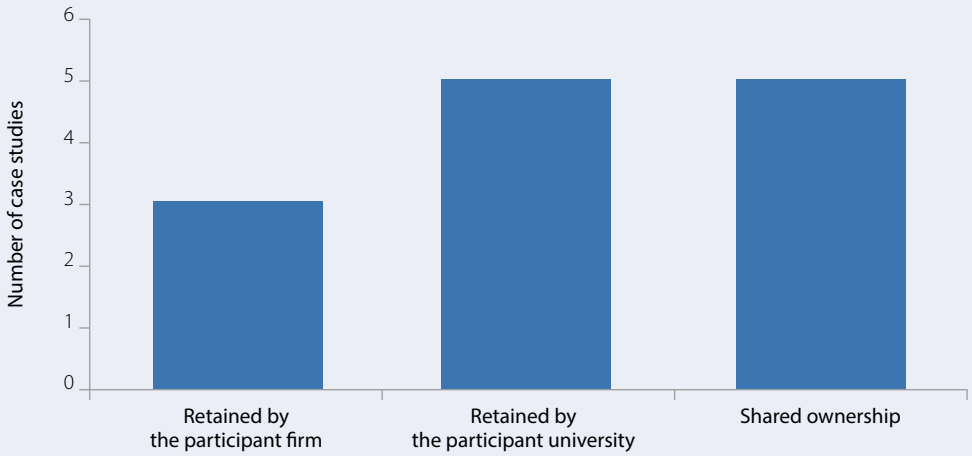
The case studies indicated that when research results did not have the prospect of immediate commercial application, the name of the business partner was generally disclosed (see Figure 9). On the other hand, when research results had the potential for commercial application, IP ownership tended to be retained either by the university, or by the university and the business partner jointly (see Figure 10). Regarding the exploitation of IP rights of research outcomes, there were a similar number of case studies in which rights were non-exclusive (six case studies) or in which they were exclusive to the participant firm (five case studies).

Figure 9. Ensuring right to publication of research results of academic value (non-commercial application)



Notes: number of responses 10/18.
Source: DOC-CAREERS II case studies – universities

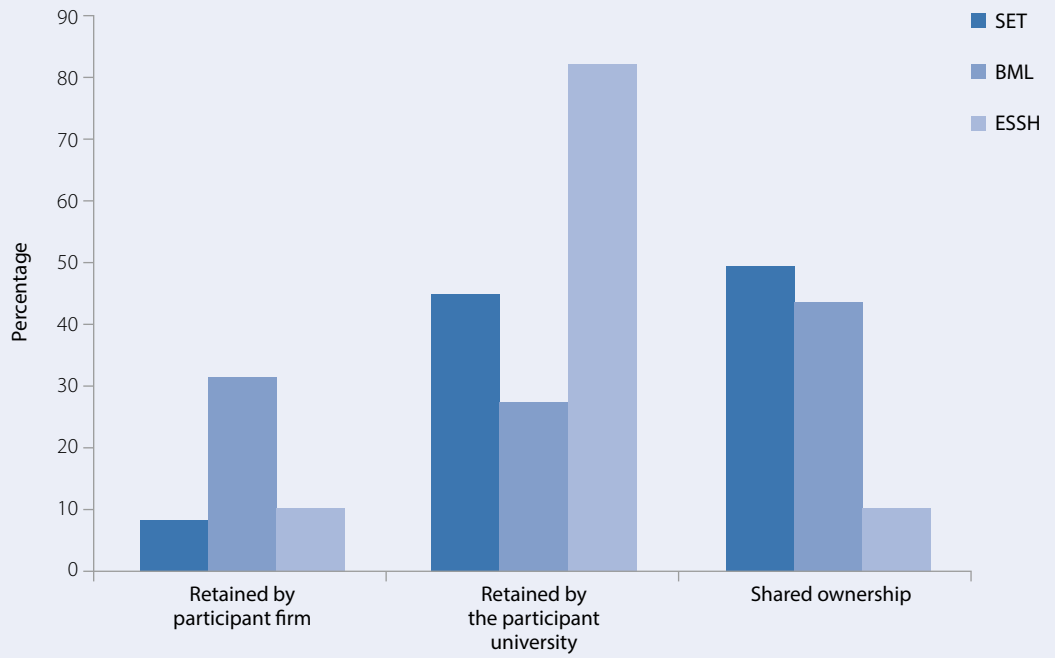
Figure 10. Protecting Intellectual Property rights for research results with commercial applications



Notes: multiple-choice question. Number of responses 9/18.
Source: DOC-CAREERS II case studies – universities

The results of the case studies also indicated that in the fields of Science, Engineering and Technology (SET) and Biotechnology, Medical and Life Sciences (BML), IP rights tended to be retained either by the university or by both the firm and the university, while in Economics, Social Sciences and Humanities (ESSH) IP rights were, in most cases, only retained by the university (see Figure 11). In the case of University College London (UCL), for example, the extent of the ownership of IP rights depended on the level of funding provided by the company – if the company did not fund the doctoral candidate, all the IP rights belonged to the candidate.

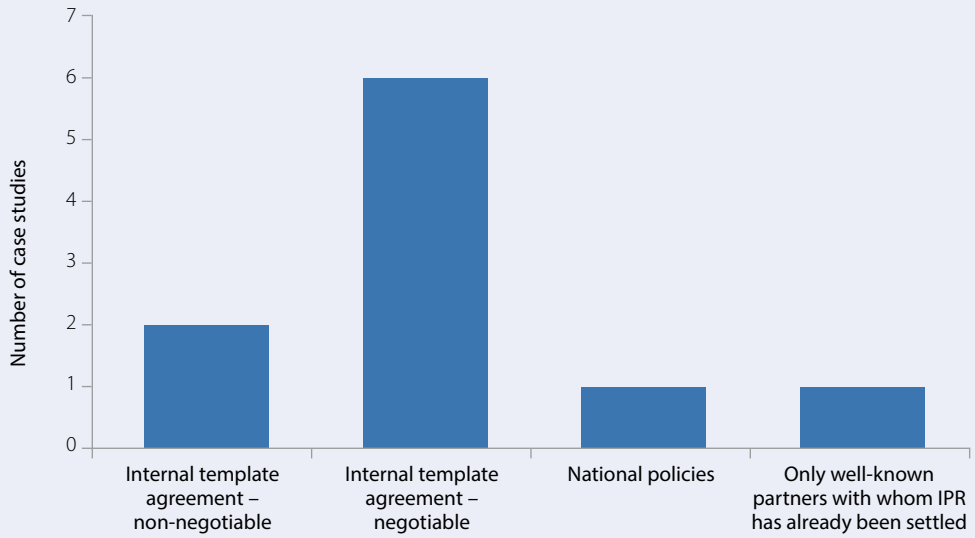
Figure 11. Intellectual Property ownership by field of knowledge



Notes: number of responses 9/18. Only universities that provided data for both questions (IP ownership and field of knowledge) were included in the analysis.
Source: DOC-CAREERS II case studies – universities

In dealing with IP rights, most universities used an internal template agreement subject to negotiation, and only in a minority of cases non-negotiable agreements were used (see Figure 12).

Figure 12. Dealing with Intellectual Property Rights



Notes: multiple-choice question. Number of responses: 9/18.
Source: DOC-CAREERS II case studies – universities

Some universities further indicated that although negotiating a collaboration agreement (including IPR) may take some time, it is an important element that helps prevent lengthy negotiations afterwards. Similar to the general agreements described earlier, standard IPR contracts/frameworks can also be used. These agreements may then be slightly modified to accommodate the needs of the university and the firm depending on the characteristics of the specific research project.

The views of universities – Examples from case studies:

Umeå University: *"IPR are different between projects and are tailor-made according to the discussions with external partners and within the legal framework of the university."*

Bangor University: *"The IPR ownership for KESS states the all IP generated by the KESS scholarship is owned by the university in order to conform with state aid regulations. However partner companies have the right to negotiate a license to exploit the IP on an exclusive or non-exclusive basis (…) This stance has played an important part in shaping the KESS programme and the type of research project undertaken, with a strong emphasis on 'evaluation research' and 'efficacy testing' (rather than explicit commercial R&D projects)."*

The views of companies – Examples from case studies:

Solvay Belgium: *"Depending on the region (ownership of researcher in Germany, option on exclusivity rfr [right of first refusal] in US, full ownership in China)."*

Skretting: *"Own policy, but negotiable."*

Oryx Simulations AB: *"Case by case so far but actively discussing now."*

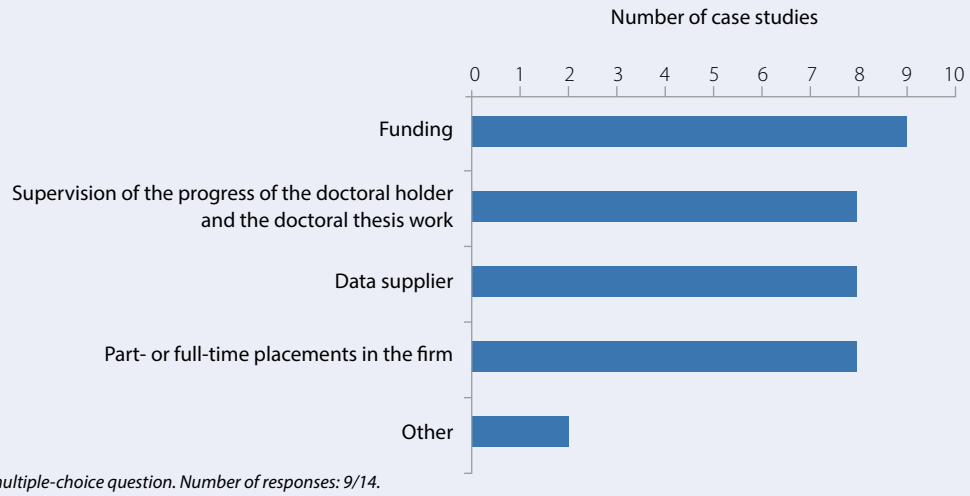
Jansen Pharmaceutica: *"Own legal document."*

GSK Biologicals: *"We try to avoid co-property as it is difficult to negotiate afterwards. Property belongs to expert companies."*

2.3.1.4 DEFINING THE COMPANY'S CONTRIBUTION TO THE COLLABORATIVE DOCTORAL SCHEME

In setting up the collaborative doctoral scheme, another important factor is defining the type of contribution the company will make to the scheme. Throughout the case studies, the most frequent type of contribution reported was funding, followed by the supervision of the doctoral research project (see Figure 13). Other types of contribution included supplying internal data for research purposes, providing placements in the firm or allowing the use of the company's facilities or equipment for the research project.

Figure 13. Types of contribution of the business partner to the collaborative doctoral scheme



Notes: multiple-choice question. Number of responses: 9/14.
Source: DOC-CAREERS II case studies – companies

In most case studies, the financial contribution of the business partner to the scheme was found to vary between 25% and 80% of the costs. Some universities also indicated that the share of private funding varied according to the size of the company, with SMEs typically contributing lower amounts than larger companies. In some of the collaborative doctoral schemes, co-funding procedures were included in the formal agreements between the university and the business.

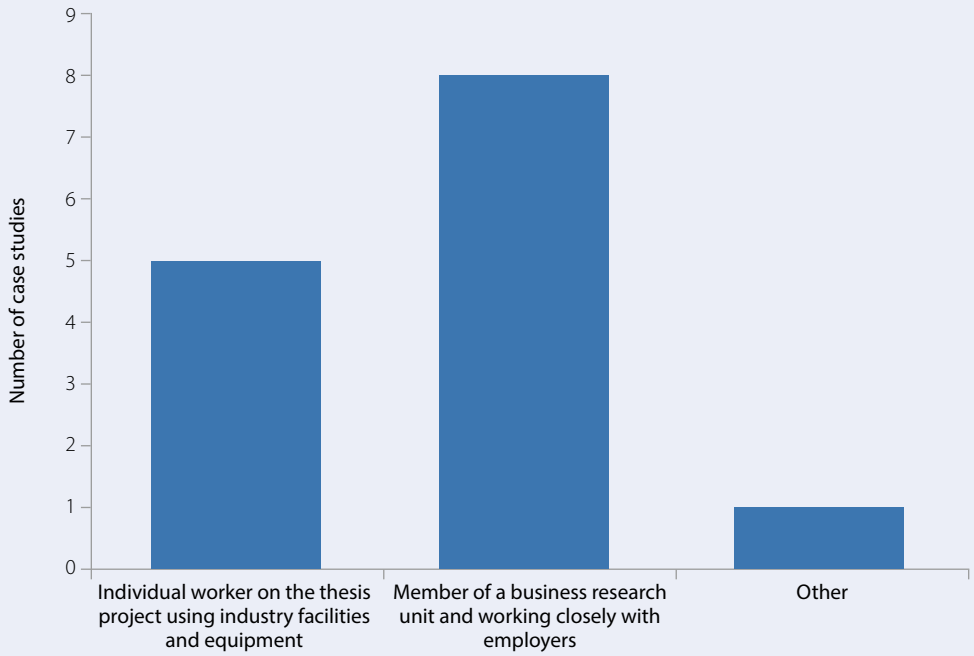
In order to cope with a possible withdrawal of the firm from the scheme, and especially to ensure that in such cases doctoral candidates had adequate resources to complete their research project, universities and companies developed several safeguard mechanisms. For example, some companies reported having formal contracts with the university to ensure the viability of the research project, having reserve funds for such situations or choosing cutting-edge doctoral research topics to ensure the continued interest of the firm in pursuing research in that particular domain. In case of company withdrawal from the scheme, many universities also provided funding to cover for the costs incurred due to the withdrawal. Some universities reported having assessed the business partner's financial situation prior to signing the collaboration agreement to ensure the financial viability of the firm and, therefore, of the collaboration/scheme.

The importance of public funding for research, including European, national and regional funds, was also highlighted by stakeholders. Public funds were perceived as essential in building the research and development (R&D) capacity of a region or a country and as a key element in developing a critical mass of researchers who are able to work both within and outside academia. The utility of public funding was also mentioned in relation to the particular case of SMEs, who may be more reluctant to engage in a collaborative doctoral scheme. Bangor University's doctoral scheme KESS (Knowledge Economy Skills Scholarships) was provided as an example of how to attract SMEs that were "not convinced" of the benefits of university-business partnerships. In this scheme, SMEs participation in the collaborative doctoral degree was associated with a low-risk research collaboration, which helped them to engage in R&D processes. The consequent challenge was the sustainability of that engagement, with regard to the development of a R&D culture within the company. To achieve sustainable university-business relations with the companies that are "not convinced", it is important that their expectations be properly managed. According to the stakeholders, this also demonstrates the importance of public funding in broadening the R&D culture in private sector companies that do not base their competitiveness in cutting-edge R&D.

Existing schemes of public funding for collaborative doctorates, in which the research agenda is set by the company, such as the French CIFRE contract and the Norwegian model (with public intervention up to 50% of total costs with the rest of the budget covered by the company) were also discussed during the DOC-CAREERS II project. Other models of funding covered in the project included doctoral theses completely funded by companies. The latter were perceived by stakeholders as a good way forward when the time between the research outcomes and their potential translation into commercial applications was short.

Regarding company placements, doctoral candidates indicated that these could occur on a full- or part-time basis during the whole thesis project or take the form of temporary placements. The results from the case studies with doctoral candidates further showed that during placements, most doctoral candidates worked as members of the firm's research unit (see Figure 14). In other cases, doctoral candidates used the company's facilities as individual workers on the thesis project.

Figure 14. Role of the doctoral candidate in business placements



Note: number of responses: 14/21.
Source: DOC-CAREERS II case studies – doctoral candidates

The views of universities – Examples from case studies:

University College London (UCL) – BIOPROCESS: *"[The company] may also provide access to industrial cell lines and large scale facilities/advanced analytical equipment."*

Ghent University: *"Large companies contribute 50%, SMEs 40 to 30%."*

University of Camerino: *"In the last two years the doctoral school established a rule for which all fellowships should be co-funded with external money (private or public that means, from companies as well as from international research projects). In chemical sciences almost all co-funding is provided by agreements with companies."*

University College London (UCL) – BIOPROCESS: *"Feedback from Engineering Doctorate (EngD) researchers suggests these placements are highly valuable for their research and their career progression."*

The views of companies – Examples from case studies:

Jansen Pharmaceutica: *"[We provide] equipment, housing, logistics."*

Intel: *"6-12 months, sometimes happens, kind of an internship."*

Umicore: *"Networking training – business partners to promote students."*

Solvay: *"Regional funding schemes (ex. Flemish region in Belgium)."*

The views of doctoral candidates – Examples from case studies:

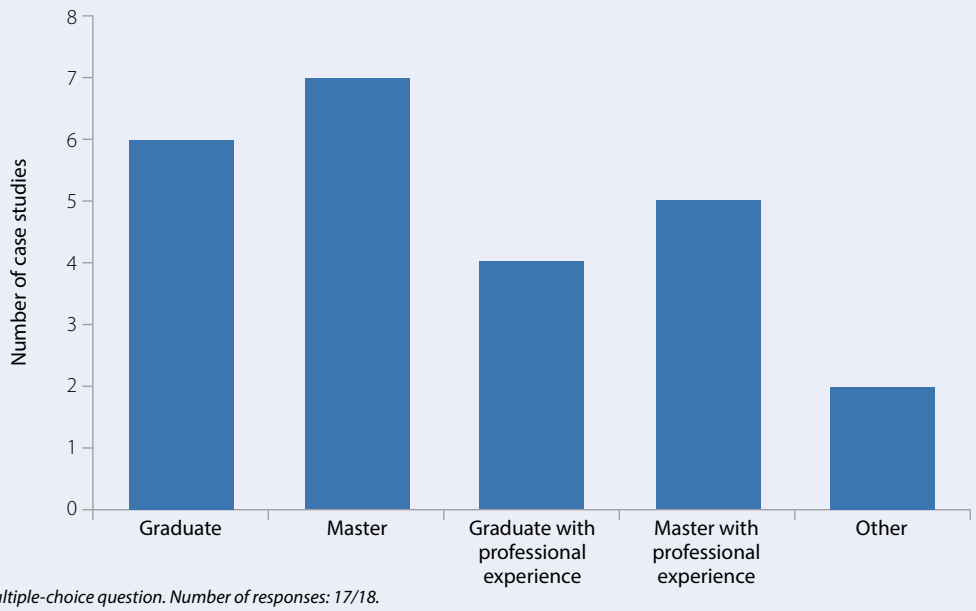
Doctoral candidate – Newcastle University: *"Short placements several weeks as and when deemed appropriate for training."*

Doctoral candidate – Norwegian University of Science and Technology: *"[Access to] facilities like the lab, pilot plant, fish trial station."*

2.3.1.5 OUTLINING THE REQUIREMENTS FOR ADMISSION

Regarding the profile of doctoral candidates enrolling in the collaborative scheme and the formal admission requirements, the university case studies results showed that the most common academic qualifications when entering the collaborative scheme was a graduate or a Master's degree (see Figure 15). However, candidates with a Master's degree and some professional experience represented a large proportion of those enrolling in collaborative schemes. This was also indicated by both the companies and the doctoral candidates.

Figure 15. Profile of doctoral candidates enrolling in the collaborative scheme



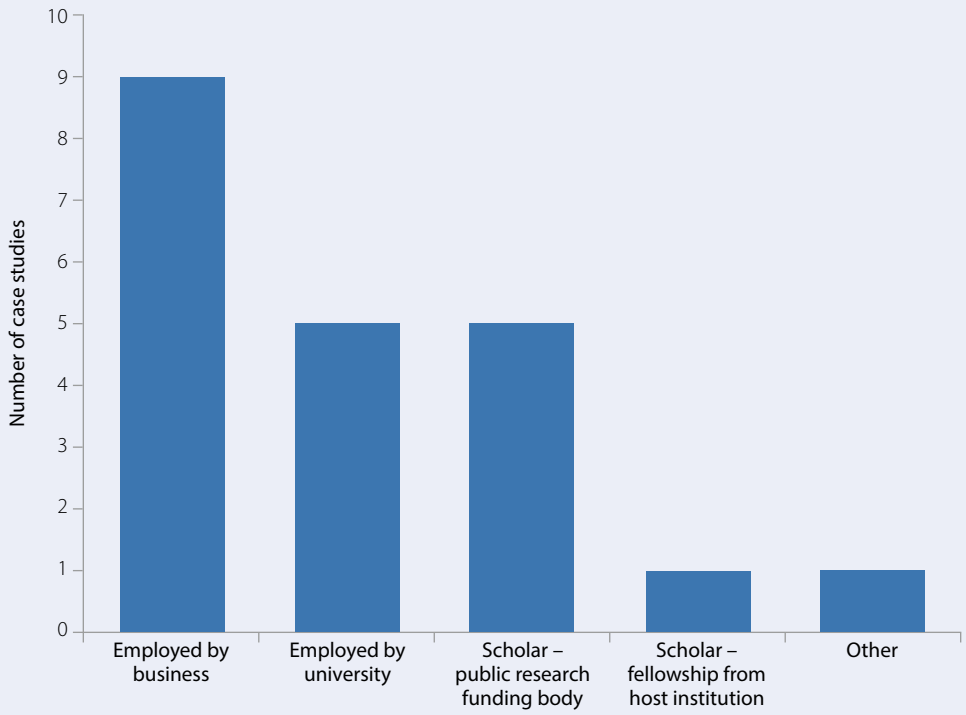
Notes: multiple-choice question. Number of responses: 17/18.
Source: DOC-CAREERS II case studies – universities

Additionally, other requirements for admission indicated by universities and companies included:

- Interviews at the university and/or industry partner;
- Previous experience in business environment;
- Knowledge of specific subject fields or scientific areas; and
- Consideration of the doctoral candidate's skills profile, particularly the ability to develop new skills.

The legal status of a doctoral candidate entering a collaborative doctoral scheme most often was that he/she was employed on part- or full-time basis by the company, followed by that of being employed by the university or being a scholar funded by a public research funding body (see Figure 16).

Figure 16. Legal status of doctoral candidates



Note: number of responses: 21/21.
Source: DOC-CAREERS II case studies – doctoral candidates

The views of universities – Examples from case studies:

Newcastle University: *"In terms of recruitment, we are seeking students who have the academic qualifications, excellent communication skills and who have undertaken additional activities over and above their degree. It is this latter feature that truly differentiates between the students."*

University College London (UCL) – SeCRET: *"Selection is based on 4 criteria: (i) fit to the DTC themes (ii) academic excellence (iii) potential for domain leadership (iv) individual's potential for gaining wider skills."*

University of Perugia: *"[The] doctoral candidate is selected by a [competition], involving (…) an interview, and the evaluation of the candidate's curriculum vitae."*

École Polytechnique Fédérale de Lausanne (EPFL): *"The EPFL doctoral candidate enjoys a double status – he/she is admitted in the doctoral programme as a student, and is a university employee supervised by the thesis director."*

The views of doctoral candidates – Examples from case studies:

Doctoral candidate – Umeå University: *"The project is at the department of chemistry, but no chemist would have managed without advanced knowledge of programming and mathematics. Computer scientists (and possibly also physicists) are probably required."*

Doctoral candidate – Newcastle University: *"Further study e.g. MSc/MRes or previous industrial experience was required."*

2.3.1.6 PROMOTING THE COLLABORATIVE SCHEME

To attract doctoral candidates, universities reported using a variety of methods to disseminate information on the collaborative doctoral scheme. These included:

- Internal university promotion
- Dissemination in events held at the university or in conferences
- Dissemination in the media
- Online promotion: university website, external websites, and
- The use of specialised information portals (e.g. EURAXESS)

More specifically, in four university case studies (University College London BIOPROCESS, University College London SeCRET, Newcastle University and Bangor University), a systematic and comprehensive marketing strategy to disseminate information on the doctoral schemes was in place. This strategy relied on a variety of dissemination activities that were used concurrently: promotion of the collaborative scheme on the university website and other external websites, marketing material and merchandising, dissemination in blogs and social networks (e.g. Facebook, LinkedIn), and informal means of promotion (interpersonal contacts).

Companies, on the other hand, engaged more frequently in direct contact with the university or used the contact network of the company to disseminate the existence of the collaborative scheme. Evidence from doctoral candidates validated these sources of knowledge. Most of them reported that initial knowledge about the scheme was gathered via the university or funding agency websites, in events held at the university or via their network of personal or professional contacts.

The views of universities – Examples from case studies:

Norwegian University of Science and Technology (NTNU): *"Different industry partners arrange "industrial days" on the university campus to come in contact with professors and students."*

Newcastle University: *"The Centre has devoted significant resources towards developing a strong brand image, using an external media design company to develop its unique logo. This branding is visible through the suite of marketing materials which have been developed to publicise the Engineering Doctorate (EngD) programme (…) multichannel approach adopted."*

The views of doctoral candidates – Examples from case studies:

Doctoral candidate – Norwegian University of Science and Technology (NTNU): *"Other colleagues had already performed successful PhD with this insurance company."*

Doctoral candidate – Skretting: *"From the Norwegian Research Council's website."*

2.3.2 DEVELOPING THE COLLABORATIVE DOCTORAL RESEARCH PROJECT

In taking forward a collaborative doctoral scheme, universities and companies identified several transversal aspects that should characterise the lifecycle of the collaboration in order to ensure its success.

Firstly, the importance of partners sharing resources and building and maintaining trustful relationships were two key aspects identified by stakeholders. Establishing a clear division of each party's role, work and milestones to be achieved was perceived by universities and companies as an essential step in the process of building long-term research collaborations.

The complementary role of the different stakeholders in taking forward the collaboration was also underlined. For instance, during the workshop dialogues participant universities underlined that the academic supervisor should focus on new scientific knowledge, the company should focus on how to use the knowledge to further their business and the doctoral candidate should be the vehicle for original research.

Another key element in ensuring the success of the collaboration concerned the profile of the individuals involved in the doctoral scheme. Stakeholders strongly emphasised the need to have committed individuals in both partner organisations – university and company – since ultimately their commitment ensured the success of the collaboration.

Finally, it was also considered that universities should check frequently with the industry partner to ensure that the collaboration was satisfactory and that the company appreciated the depth of scientific knowledge brought by doctoral candidates/holders.

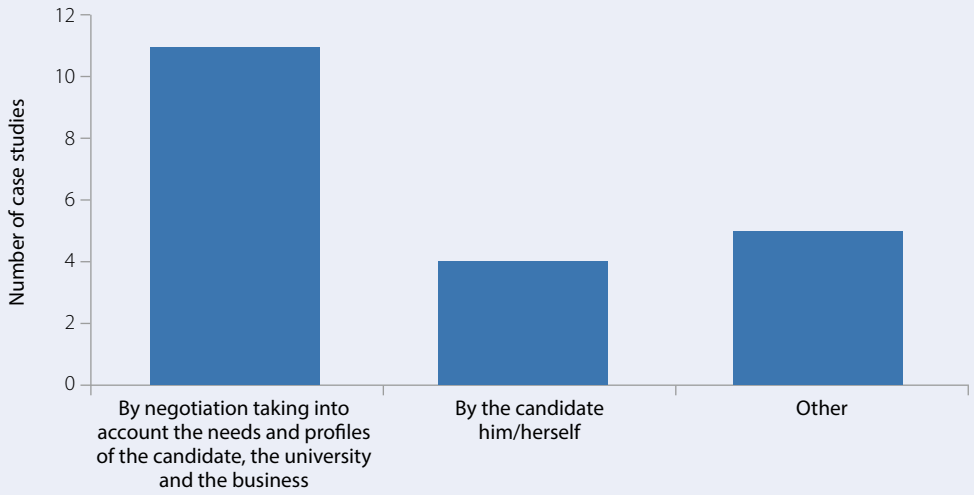
Besides these transversal elements that should characterise the process of taking the scheme forward, other more specific elements and stages should also be taken into consideration. These aspects relate to:

- The choice of the doctoral research topic
- The supervision process
- Monitoring the progress of the doctoral research work.

2.3.2.1 THE SELECTION OF THE DOCTORAL RESEARCH TOPIC

According to the DOC-CAREERS II case studies, the selection of the doctoral research topic was most frequently undertaken by negotiation considering the different needs and interests of the university, the business partner and the doctoral candidate (see Figure 17). Less frequent was the choice of the research topic jointly by the university and the firm, or solely by the doctoral candidate. Several universities added that involving the doctoral candidate in the choice of his/her research topic was extremely important for the successful completion of the project.

Figure 17. Selection of the doctoral research topic



Notes: multiple-choice question. Number of responses: 17/18.
The category "Other" includes cases in which the research topic was chosen by the university and the business partner.
Source: DOC-CAREERS II case studies – universities

Universities further cautioned against the doctoral research topic being overly determined by the business partner. When a company suggests a research topic, it is important to assess if this project contains enough scientific challenges for proper doctoral research content. Universities further added that the doctoral candidate should be protected from being involved by the partner in too much "applied" research, which could potentially divert him/her from his/her original research focus and hence compromise the academic value of his/her research and thus his/her chances to earn the doctorate degree at the end of the research period.

The views of universities – Examples from case studies:

Newcastle University: *"The approach for project allocation (…) comprises 3 stages. The first stage is to recruit outstanding students (…) and through the interview process identify their areas of interest in research, industrial focus and whether they prefer an SME or multinational. In parallel to student recruitment, the Director and co-Director meet with, and discuss research opportunities with potential industrial collaborators. The next stage is to match a number of potential students (typically 3) against each potential project and it is then the role of industry to interview and make the final selection in student recruitment. The SSC [Strategic Steering Committee] is responsible for confirming the alignment of the research project to the Engineering Doctorate (EngD) programme area and that the research challenges are of an appropriate level."*

The views of doctoral candidates – Examples from case studies:

Doctoral candidate – Ghent University: *"First the business proposed a broad research topic. Together with the university and my supervisor, we sorted out the details."*

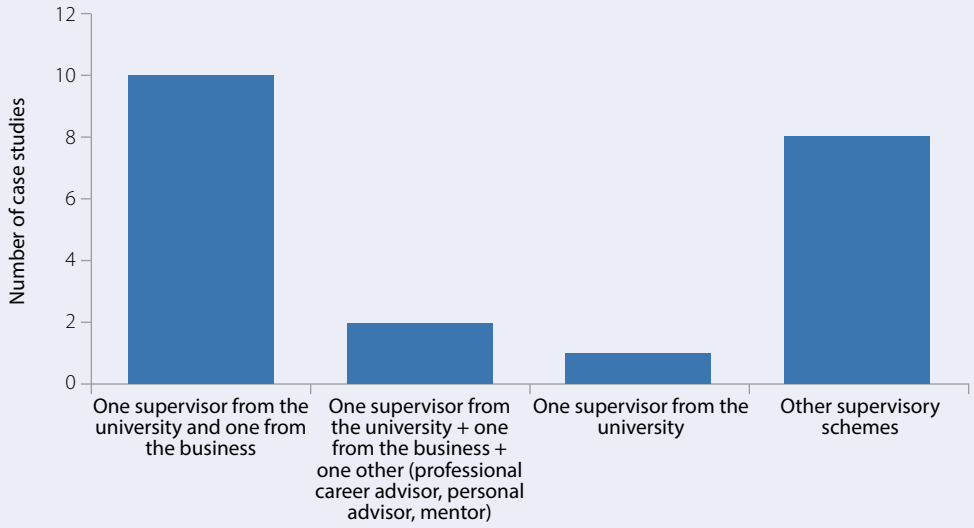
Doctoral candidate – Ghent University: *"The general research domain was fixed by the job contract, the more precise direction is determined cooperatively by my supervisors at NICC and the university and myself."*

2.3.2.2 THE SUPERVISION PROCESS

One of the main distinctive characteristics of collaborative doctoral schemes is the supervisory arrangement. Essentially, what differentiates a collaborative doctoral programme from a traditional doctoral programme is the composition of the supervisory scheme: in collaborative schemes, an industrial supervisor must be involved in the supervision and follow-up of the doctoral research in addition to the university supervisor.[13]

The results of the case studies conducted with universities, businesses and doctoral candidates confirmed this point. Indeed, virtually in all the reported cases, doctoral candidates had a supervisor from the university and a supervisor from the business partner (see Figure 18). There were also several cases in which doctoral candidates had more than one academic supervisor (either from the same or from different departments/scientific areas) in addition to the company supervisor.

Figure 18 . Supervisory scheme



Notes: multiple-choice question. Number of responses: 17/18. The category "other supervisory schemes" encompasses a variety of situations, including cases in which doctoral candidates have two supervisors from the university (from the same or from different departments/scientific fields) in addition to the supervisor from the business partner, or situations in which there are several supervisors from the university and the business with different supervisory responsibilities.
Source: DOC-CAREERS II case studies – doctoral candidates

Universities, in particular, emphasised that although in collaborative schemes the business supervisor is involved in the supervision and follow-up of the doctoral research, the academic supervisor remains the ultimate person responsible for leading and ensuring the successful completion of the doctoral research project and for the scientific soundness and quality of the research conducted. As the final person responsible for the scientific value of the project, the academic supervisor needs to ensure the project is of sufficient/appropriate academic quality to earn a doctorate degree.

All stakeholders considered that regular contact among all partners was extremely important to ensure an adequate progress of the collaborative doctoral project. Proximity and constant communication between the doctoral candidate, the company and the university was perceived as essential to minimise misunderstandings or to address mistrust. Proximity was also seen as of paramount importance in terms of balancing the structure and flexibility needed to develop a collaborative doctoral research project.

[13] Borrell-Damian, L., 2009, *Collaborative Doctoral Education. University-Industry Partnerships for Enhancing Knowledge Exchange. DOC-CAREERS Project* (Brussels, EUA). www.eua.be

Regarding the supervision process itself, the outcomes of the case studies showed that the frequency of meetings between the doctoral candidates and the university or business supervisors varied widely. In general, most meetings occurred on a need-basis and no fixed frequency was stipulated. Therefore, meetings could occur daily, monthly, every three months or just once a year. An important aspect that emerged in the case studies was that doctoral candidates who were employed by the business partner typically met with the company supervisor much more frequently than doctoral candidates who were not based in the company. Meetings involving all stakeholders – doctoral candidate, university supervisor and industrial supervisor – were also held with varying frequency.

The views of universities – Examples from case studies:

University College London (UCL) – CoMPLEX: *"KESS Scholars usually have a second academic supervisor in addition to their lead academic supervisor and their industrial supervisor. This can be another academic from the same department who acts as a research mentor for an early stage researcher. It can also, in the case of multidisciplinary projects, be a relevant academic from a different department."*

Newcastle University: *"Monthly meetings are held between the student and the industrial and academic supervisors – these are typically via teleconference. On a three monthly basis, a face-to-face meeting is held involving the same parties as for the monthly meeting but with the project sponsor present to ensure the research is on track from a business and research perspective."*

The views of companies – Examples from case studies:

Skretting: *"If [the doctoral candidate is an] employee we spend more time – daily contact in-house. In university it depends – case by case basis, but normally monthly."*

The views of doctoral candidates – Examples from case studies:

Doctoral candidate – Newcastle University: *"Two academic supervisors, one industrial and one associate from another business that doesn't supervise but contributes."*

Doctoral candidate – Norwegian University of Science and Technology (NTNU): *"For all project participants, the physical meetings are organised twice a year."*

Doctoral candidate – University of Perugia: *"We organise a monthly meeting to evaluate the progress of the research and new applications of our product."*

2.3.2.3 MONITORING THE PROGRESS OF THE DOCTORAL RESEARCH WORK

Universities, companies and doctoral candidates considered that systematically monitoring the progress of the doctoral research project was a very important step in ensuring the success of the collaborative research project. The stakeholders considered that although the experiences of doctorates based in a university or in a company may be very different, it is essential for the supervisory relationships and processes, namely monitoring, to be adequate.

The majority of universities participating in the case studies reported holding formal monitoring activities once a year or, in some cases, twice a year.

According to the universities taking part in the project, relevant monitoring elements and activities should include:

- An outline of the doctoral research project
- An annual review to monitor the progress achieved and to establish future research milestones
- Regular (e.g. monthly, quarterly) supervisory meetings with key contact persons of the university and the company
- Simulations of thesis examination

During the workshops conducted as part of the DOC-CAREERS II project, participants indicated that doctoral supervisors could benefit from specific "peer-to-peer" training to tutor candidates involved in collaborative doctoral processes.

Regarding the issue of non-completion of the doctoral programme, both universities and companies indicated that this situation rarely occurred, even though no quantitative information was available. In the few reported cases, the most frequent reason for non-completion identified by universities and companies related to changes in the personal situation of doctoral candidates, such as change of job or country. The lower financial remuneration offered by scholarships for academic research compared to the salaries doctoral candidates could earn in the private sector was also indicated as a possible reason for doctoral candidates not completing the programme in some cases.

The views of universities – Examples from case studies:

University College London (UCL) – CoMPLEX: *"CoMPLEX conducts an annual review in which all students meet with two CoMPLEX staff, who review the progress and work plan. [This is] agreed after a meeting with the student and both supervisors."*

The views of doctoral candidates – Examples from case studies:

Doctoral candidate – Ghent University: *"Specific agreements were made to sit together regularly and discuss the progress of the project (positive points and bottlenecks). As a result both partners keep in touch and both supervisors have insight into the progress of the project right from the start."*

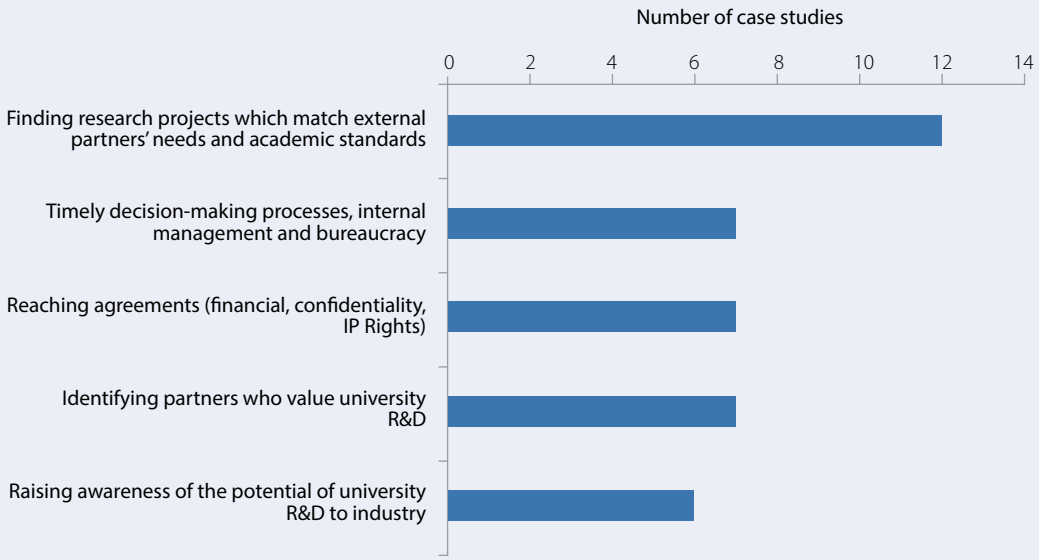
Doctoral candidate – University College London (UCL): *"[Progress reviews] are very useful in terms of assessing progress and also in highlighting any training requirements. In general, progress reviews with UCL academic supervisors occur monthly and those with GSK every three months. "*

2.4 WHAT MAKES FOR A SUCCESSFUL COLLABORATIVE SCHEME? IDENTIFYING AND OVERCOMING CHALLENGES

Many of the challenges identified in establishing and taking forward a successful collaborative doctoral scheme were shared by universities, companies and doctoral candidates.

The most common challenges encountered by universities included finding a research project that simultaneously matched business needs and academic standards (see Figure 19). Universities further indicated that a good academic idea for the doctoral research project is not necessarily considered good for the market at that particular time, and that a proper balance of the academic and business relevance of the research topic should be sought.

Figure 19. Challenges in establishing the collaborative doctoral scheme

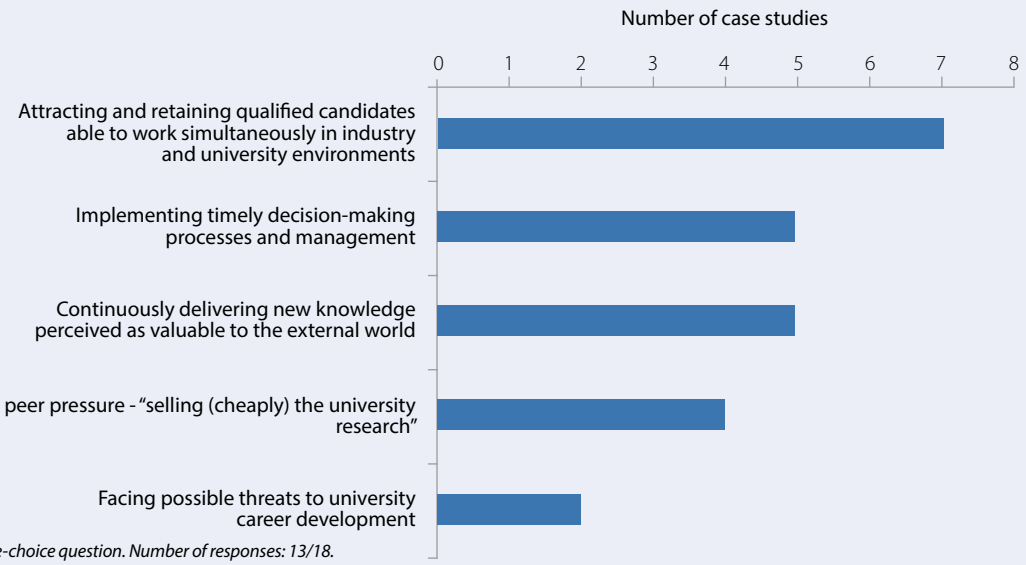


Notes: multiple-choice question. Number of responses: 15/18.
Source: DOC-CAREERS II case studies – universities

Other challenges included reaching formal agreements between the parties, identifying collaboration partners that value research, and increasing awareness of the value of research for the business sector. This latter point was particularly highlighted in relation to SMEs, since larger companies are typically more aware of the value of research. Other difficulties encountered by universities were related to the negotiation and management phases of the project. More specifically, universities highlighted that ensuring that decision-making processes are expedient and well-timed in consonance with the other partners was a challenge.

Indeed, lengthy decision-making processes and excessive bureaucratic procedures were some of the main challenges identified by both universities and companies when establishing and taking forward a collaborative doctoral scheme (see Figure 19 and Figure 20). The mismatch in the decision-making timeframe of universities and companies can delay the establishment and development of the partnership.

Figure 20. Challenges in taking forward the collaborative doctoral scheme: the perspective of universities



Notes: multiple-choice question. Number of responses: 13/18.
Source: DOC-CAREERS II case studies – universities

Table 3: Challenges in taking forward the collaborative doctoral scheme – the views of companies

- Ensuring commitment to take the partnership forward
- Identifying suitable people at the company to supervise the doctoral research
- Identifying doctoral candidates with the right skill profile
- Agreeing on IPR arrangements
- Ensuring funding continuity

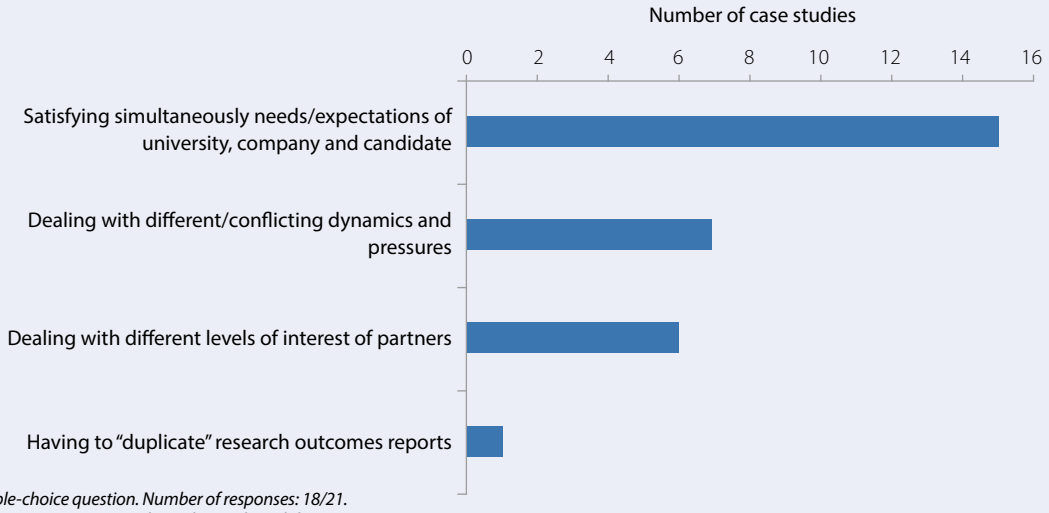
In taking forward the collaborative scheme, universities and companies both (Table 3) highlighted the importance of identifying doctoral candidates who are able to work simultaneously in both sectors. A related challenge was the identification of suitable individuals at the university and in the company who were able to supervise a collaborative project, since this scheme requires a specific set of skills and competences. That is, the university supervisor must understand the objectives and constraints of the business sector, and the company supervisor needs to be knowledgeable about what pursuing a doctoral degree entails, namely the scientific standards that doctoral candidates need to meet in order to be awarded the degree.

Obtaining adequate long-term funding to establish and sustain the collaborative scheme was also identified by both universities and companies as a challenge and a key aspect that is important for the success of the collaborative scheme. In addition, the stakeholders also considered that, because doctoral collaborations may have a tendency to drift in time and scope, there is a need to put in place safeguard mechanisms. Examples of such mechanisms related to clearly defining the course of actions to be taken and identifying the responsible partner for providing extra funds should the doctoral project extend beyond the established time or funding. Other aspects referred to the need to find the right balance in the time doctoral candidates spend at the university and in the business partner premises and the need to reach agreements on IPR at an early stage of the collaboration process.

To ensure the success of the collaborative scheme, universities and companies underlined that all parties should be strongly committed to take the partnership forward. This point was particularly emphasised by the business sector. The stakeholders also stressed that the collaboration between the company and the university should be seen as complementary, with each partner bringing its own expertise to the

different tasks in the process. In doing so, all stakeholders – university, company and doctoral candidate – need to understand and balance the needs, expectations and objectives of each other, and to find common ground to solve the challenges arising during the partnership. Indeed, for doctoral candidates, being able to manage and meet different, and sometimes conflicting, expectations of the university and the company partner was the most important challenge involved in pursuing a collaborative doctoral degree (Figure 21).

Figure 21. Challenges in undertaking a collaborative doctoral degree: the perspective of doctoral candidates



Notes: multiple-choice question. Number of responses: 18/21.
Source: DOC-CAREERS II case studies – doctoral candidates

Other difficulties included managing the different constraints in the academic and business environment, coping with varying levels of interest from the university and business partner and, less frequently, the need to produce several reports on the progress of the research work, tailored to the differing needs of the university, company and/or funding agency. Some doctoral candidates also mentioned time management challenges, i.e. finding the right balance of time spent in the company and at the university or adapting to the heavy workload of the doctoral research work.

Another point related to pursuing a collaborative doctoral degree is the development of research in the context of a team. Universities participating in the project cautioned that while teamwork is typically a skill highly appreciated by companies, in doctoral education there is a limit to this concept: the research outcomes not only have to be original but also have to be originated by the doctoral candidate him/herself.

Overall, the outcomes of the DOC-CAREERS II project suggest that to overcome the above challenges, universities, companies and doctoral candidates need to take into account the following aspects:

- Actively involve the relevant stakeholders in all the lifecycle stages of the collaborative doctoral scheme, that is, from inception to completion;
- Thoroughly plan the doctoral scheme, paying particular attention to the definition of common goals, objectives and expected outcomes, negotiating the partnership (including IPR); and
- Building a shared vision of the scheme, developing trustful relations and ensuring continued contact and feedback among all partners.

The views of universities – Examples from case studies:

École Polytechnique Fédérale de Lausanne (EPFL): *"Different objectives, and different needs, which translate in different approaches and different timeframes. In these lies a risk of misunderstanding between the partners. There is therefore a need for an equilibrium that both partners need to find in the preparation of the collaboration: adapting the subject, identifying key people, keeping the long-term view of the project."*

Dublin Institute of Technology: *"…challenges were avoided from the start by including all partners in the design of the scheme from day one. The ethos of the scheme is that it breaks down boundaries between researchers, practitioners, professionals, policy makers, industry and the community by developing a dynamic research programme enabling collective identification of the research problems and solutions."*

The views of companies – Examples from case studies:

GSK Biologicals: *"To companies: good collaborative academic lab and the company – you have to meet informally lots of times to build trust and not to leave the student alone."*

Skretting: *"Some universities are used to having industrial PhD, some not. Sense of urgency is lacking in university."*

Solvay Belgium: *"Long-term meaning-commitment/people."*

The views of doctoral candidates – Examples from case studies:

Doctoral candidate – Umeå University: *"I believe it's one of the most frustrating tasks of a PhD student located in industry and working with industrial tasks to combine and balance the interests and needs of industry and academia."*

Doctoral candidate – Ghent University: *"Early feedback about this balance from both sides makes this challenge manageable and improves the usefulness and quality of the research results."*

2.5 IMPACT AND SUSTAINABILITY OF THE COLLABORATIVE DOCTORAL SCHEME

The outcomes of the DOC-CAREERS II project revealed that collaborative doctoral programmes are increasingly important and many governments in Europe are developing their own schemes to foster this type of research partnership. In addition, collaborative doctoral education was considered by practitioners as a good way to test university-business research collaborations.

In spite of this, the stakeholders noted that many academics and companies are still reluctant in engaging in university-business partnerships. To provide additional incentives for the development of these activities, the participants in the project suggested that "peer-to-peer" activities from company-to-company

and university-to-university could help those not yet sure of the value and benefits of partnerships to participate in activities that strengthen the link between academia and the business sector. The potential higher impact of collaborative doctoral programmes in the sense that they respond directly to the partners' needs and that research results have a direct application in the business sector, are two important elements that could persuade those who are currently resistant to engage in collaborative activities to do so in future. In addition, the project participants also underlined the fact that the characteristics of the collaborative scheme allow opportunities for further knowledge transfer between the academic and the business sectors.

The stakeholders also noted that the impact of research outcomes is as important in ESSH disciplines as it is in the so-called "hard sciences" disciplines (SET, BML) although in the former it may be more difficult to quantify. The unpredictability of research outcomes in some scientific areas also poses challenges in establishing partnerships. However, these aspects should not hamper the development of university-business collaborations as partnerships in the ESSH fields also bring about important added-value outcomes for the partners involved (e.g. consultancy services and exchange of expertise among partners). For example, in the workshops, the importance of partnerships in the media, cultural and creative sectors involving universities, non-governmental organisations and philanthropic organisations was explored.

Overall, the project findings revealed that all stakeholders – universities, companies and doctoral candidates – perceived a wide range of benefits in collaborative doctoral education and assessed its outcomes very positively. For doctoral candidates, this was mainly due to the opportunity to develop research in an industrial/business environment and the increased chances of gaining employment in that sector. For companies, a collaborative doctoral scheme was seen as an opportunity to increase the competitiveness of their research activities and to explore new lines of research within the company. The collaborative scheme was also perceived as a valuable opportunity to test and recruit potential employees and to develop a network of contacts within the university. For universities, the opportunity to establish closer ties with the business sector, to create more funding opportunities and the increased attractiveness of the institution were aspects that were also highlighted. Collaborative doctoral schemes were also perceived as having a positive impact at the regional and national level. Indeed, closer ties between the universities and the businesses leading to successful collaboration worked to both enhance the competitiveness of companies and the reputation and visibility of the university, which in turn contributed to attracting more students and to providing companies with a broader, highly skilled pool of candidates.

The results of the majority of the case studies indicated that formal systems to monitor and assess the impact of the collaborative scheme were, during the course of the project, limited or in process of development. In the case of the Dublin Institute of Technology a more structured approach in assessing the impact of the scheme was in place. This university used a variety of indicators to evaluate the effects of the collaborative scheme on doctoral candidates, the university, the company and the city/region. For doctoral candidates, the assessment indicators included: time to complete the thesis, time the candidate needed to get the first job, amount of the first salary and promotion trends. For the university, the assessment was made considering the annual number of doctoral degrees awarded, the number of collaborations, publications (e.g. peer-reviewed publications and reports), number of disclosures, licenses, patents, spin-off companies established and the amount of research funding obtained. For companies, the number of disclosures, patents and licenses was considered, along with the number of new products and services, market expansion and profits. Finally, the impact on the city/region was assessed through the use of research results.

Most of the universities and companies involved in the DOC-CAREERS II project reported holding informal activities to assess the impact of the scheme, such as joint seminars, conferences or more general events bringing together all stakeholders. Tracking the professional path of doctorate holders from collaborative schemes was also used by some universities, although this was not a widely shared practice.

Another aspect that the DOC-CAREERS II project highlighted was that universities should consider how to ensure the means to sustain the collaborative scheme. The large majority of universities and companies participating in the project expressed the intention of pursuing further the research collaboration. Even though all schemes faced some type of constraints, the most frequent limitation was funding as its continuation from either public or private sources was not ensured on a long-term basis. Collaborations are typically limited to time-specific programme budgets of organisations or companies, whose ownership and strategic concerns may change over time. To overcome this limitation, many universities were actively seeking to expand the funding sources of the collaborative schemes. This mainly entailed broadening the funding sources to include more participation from the private sector, research funding agencies or charities. Funding was also perceived by stakeholders as an important incentive to engage in university-business partnerships, since companies would be less likely to invest in speculative projects if they needed to cover the full cost of the projects. In this context, public funding was perceived as extremely important in fostering university-business partnerships.

The views of universities – Examples from case studies:

University College London (UCL) – BIOPROCESS: *"Feedback from our Industrial Training Advisory Board (comprising 30 bioindustry professionals and which meets annually) suggests our Engineering Doctorate (EngD) graduates have a major impact in industry. We have, via completed EngD collaborations, delivered new generic technologies, which help to reduce time to market through novel UCL bioprocessing methods. Some companies have achieved up to a 50% reduction in development time. Other companies have used our methods to support new manufacturing licence applications for new therapies while emerging regenerative medicine companies are using EngD outputs to rapidly explore options for bringing entirely new types of human cell therapy to market."*

Bangor University: *"KESS has commissioned an ongoing external evaluation. This will look at how all participants (academic and industrial partners and doctoral candidates) have benefitted and how the project has met its stated objectives. The evaluation will provide a mid-term report and annual progress reports before providing a comprehensive final report at the end of the project."*

Umeå University: *"The graduate school has recently started and a monitoring process is not yet in place, but under development."*

The views of companies – Examples from case studies:

Biotalentum: *"We are new to this, we have no analyses yet, but because of the EU projects (Marie Curie programme) we are preparing the first report now. It is a 5-year sponsored programme."*

Skretting: "*Relatively new for us. Indirect assessment. No monitoring system. We are happy right now."*

The views of doctoral candidates – Examples from case studies:

Doctoral candidate – University College London (UCL): *"Most valuable are the contacts formed in industries that can be quite inaccessible to external researchers."*

Doctoral candidate – Norwegian University of Science and Technology (NTNU): *"Obtained results can find immediate application since they are equally driven by academia and business sector."*

3 COLLABORATIVE DOCTORAL EDUCATION AND EMPLOYMENT OPPORTUNITIES FOR RESEARCHERS

Throughout the DOC-CAREERS II project, particular emphasis was placed on exploring the enhanced employment opportunities for doctorate holders in the non-academic sector. Participant universities, companies and doctoral candidates/holders considered that a doctoral degree clearly enhanced the employment prospects of the doctorate holder in the non-academic sector and was instrumental in the career development of these professionals. More specifically, a collaborative doctoral degree may increase the professional opportunities of individuals in the non-academic sector by broadening the spectrum of potential positions and sectors and by enhancing the likelihood of reaching higher positions in the organisation in the long-term. On a more general level, the stakeholders in the project also noted that collaborative doctoral programmes could contribute to the personal and professional development of the population through research, by building the R&D capacity of a region or country.

The companies involved in the project specified that taking part in a collaborative doctoral scheme resulted in a boost to the firm's innovation capabilities, the opportunity to train doctoral candidates as future employees and the chance to gain access to new markets. Doctoral candidates/holders working in companies were viewed as a source of new ideas, and as important agents in contributing to the development of new areas of research in the company and in exploring potential research applications.

All the stakeholders considered that doctorate holders who graduated from a collaborative scheme had a better chance to secure employment in the non-academic sector than doctorate holders from a traditional programme. This was mainly due to their ability to bridge the gap between the university and business sector, being "bilingual" in both sectors, and the transversal skills they gained while working on the doctoral thesis. Indeed 67% (14 out of 21) of the doctoral candidates that took part in the case studies felt they had more employment opportunities in the business sector compared to their colleagues from traditional doctoral programmes. Many of them also considered that the chances of being offered a position in the partner company of the scheme were good, a view corroborated by many universities and companies.

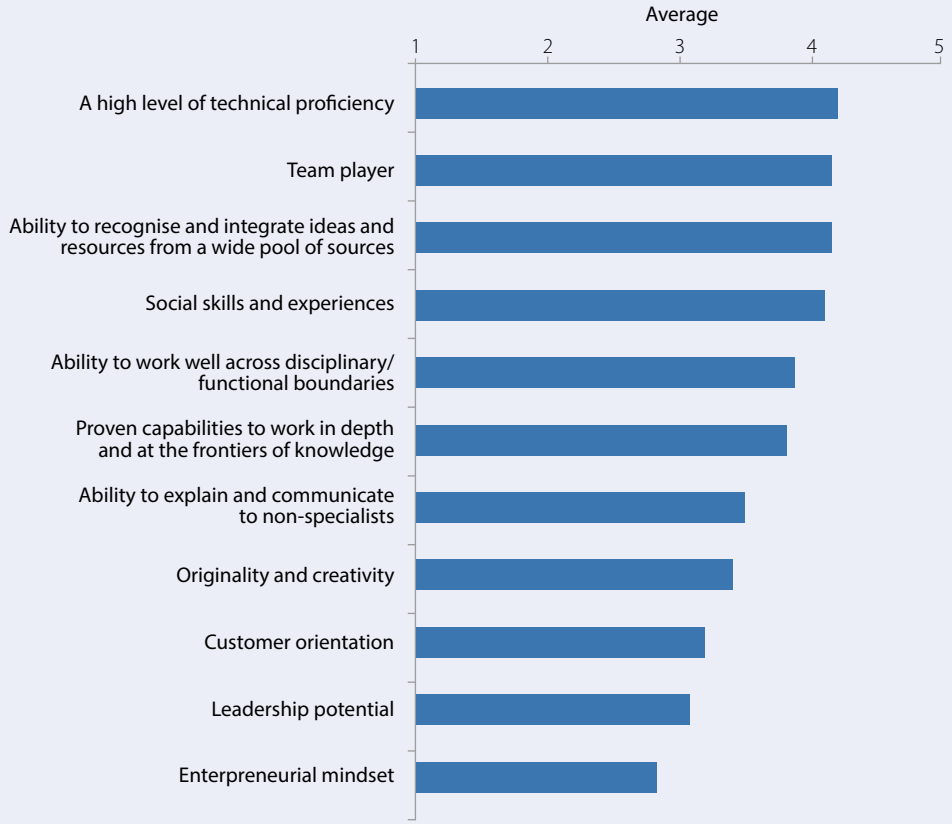
The firms also added that their capability to recruit a doctorate holder after the collaborative scheme depended mainly on the company's activity and capacity for long-term projects. In this respect, it was indicated that collaborations between universities and SMEs still remained challenging, due to mainly financial constraints and the absence of a person who could supervise a doctoral research project (except in the case of intensive knowledge-based companies). As a potential strategy to overcome this situation, universities suggested that collaborations at Master's level with joint supervision would be easier to achieve for SMEs. This was because Master's research projects were typically shorter in duration and closer to the market, which increased the added-value of the research conducted vis-à-vis the company's activities, and it entailed a lower risk to the firm. This would allow the necessary build-up of a long-term relationship between the SME and the university based on mutual trust, which could then serve as a catalyst to more long-term partnerships.

3.1 RECRUITMENT OF DOCTORATE HOLDERS: THE PERSPECTIVE OF THE BUSINESS SECTOR

When companies decide to recruit a doctorate holder, they typically look for a skill profile characterised by deep technical expertise, problem solving and analytical competences, such as integrating ideas from a variety of different sources (see Figure 22). Social skills were also considered important, namely being a "team player", while leadership potential and an entrepreneurial mindset were assessed as moderately important when recruiting doctorate holders.

The skills and competences of doctoral holders presented in Figure 22, which include a mix of cognitive, social and communication skills, are broadly in line with existing frameworks for the professional development of researchers. For example, Vitae – an organisation from the United Kingdom – has created the *Researcher Development Framework,*[14] a comprehensive scheme focusing on the "knowledge, behaviours and attitudes" of researchers. Another example, *DocPro,*[15] created by three organisations, including the French Rectors' Conference, consists of a framework of competences developed by doctoral candidates during their studies. Both these frameworks highlight the variety of skills and competences of doctoral holders, which make them well-rounded professionals.

Figure 22. Average importance of skills required from doctorate holders at the time of recruitment



Notes: The scale ranges from 1 (low importance) to 5 (high importance). Number of respondents: 10/14.
Source: DOC-CAREERS II case studies – companies

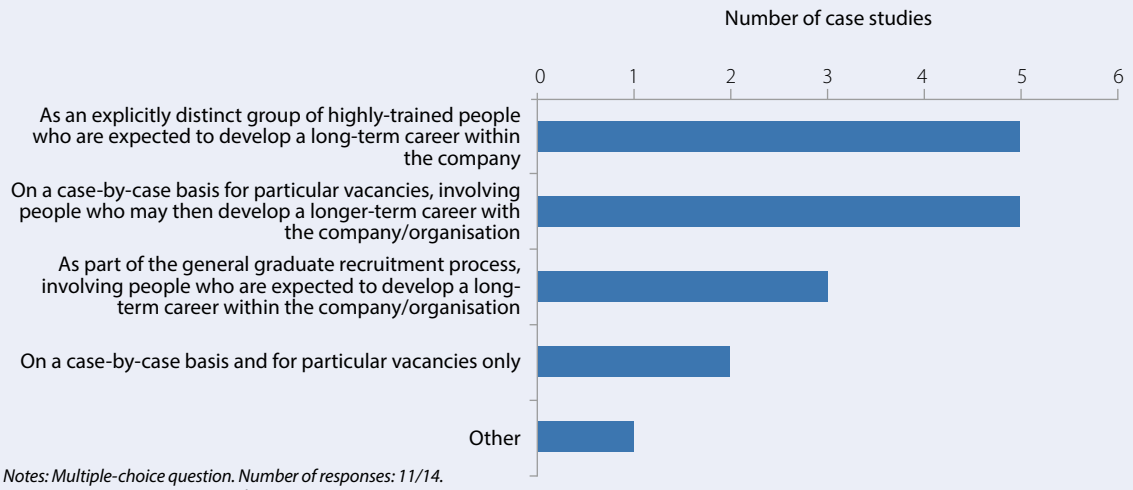
Some companies also indicated that there is sometimes a tension between the global and local recruitment of highly skilled professionals, such as doctorate holders. While they may be extremely strong in scientific

[14] https://www.vitae.ac.uk/researchers-professional-development/about-the-vitae-researcher-development-framework/developing-the-vitae-researcher-development-framework
[15] http://www.mydocpro.org/en

skills, they can experience difficulties in adapting to working in companies based abroad due to language, societal/ethical or cultural differences.

According to the results of the case studies, when companies decide to recruit doctorate holders they consider them, mostly, as a distinct group of highly trained graduates who are expected to develop a long-term career in the company (see Figure 23).

Figure 23. Recruitment modes of doctorate holders

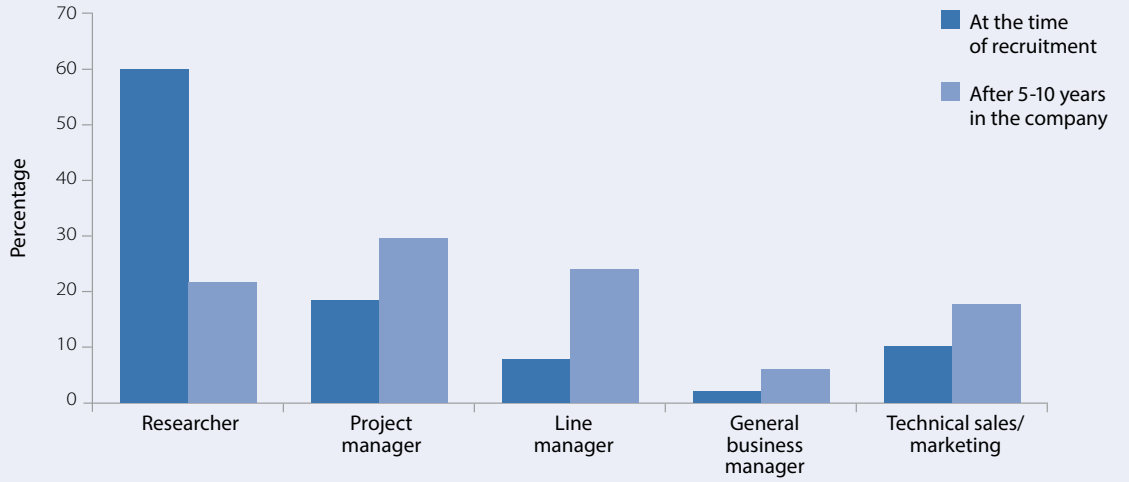


Notes: Multiple-choice question. Number of responses: 11/14.
Source: DOC-CAREERS II case studies – companies

Recruitment of doctorate holders on a case-by-case basis, who may then develop a long-term career in the company, was also frequent. However, companies also indicated that the particular requirements of the vacancy and the need for a highly specialised workforce to cope with the long-term challenges that companies face is what usually underpins the recruitment of doctoral candidates.

Comparing these results to those found in the first DOC-CAREERS project, the pattern of companies' responses is broadly identical. However, the results of DOC-CAREERS II show an increase in the recruitment of doctoral holders "with a view for a long-term career in the company" and also as a "distinct group of highly trained people who are expected to develop a long-term career in the company". In addition, the results indicated a decrease in the recruitment of doctoral holders on a case-by-case basis for particular vacancies, compared to the results found in the first DOC-CAREERS project.

Figure 24. Professional profiles of doctorate holders at the time of recruitment and in the medium-term



Notes: Number of respondents 13/14 for the category 'at the time of recruitment'; 10/14 for the category 'after 5-10 years in the company'.
Source: DOC-CAREERS II case studies – companies

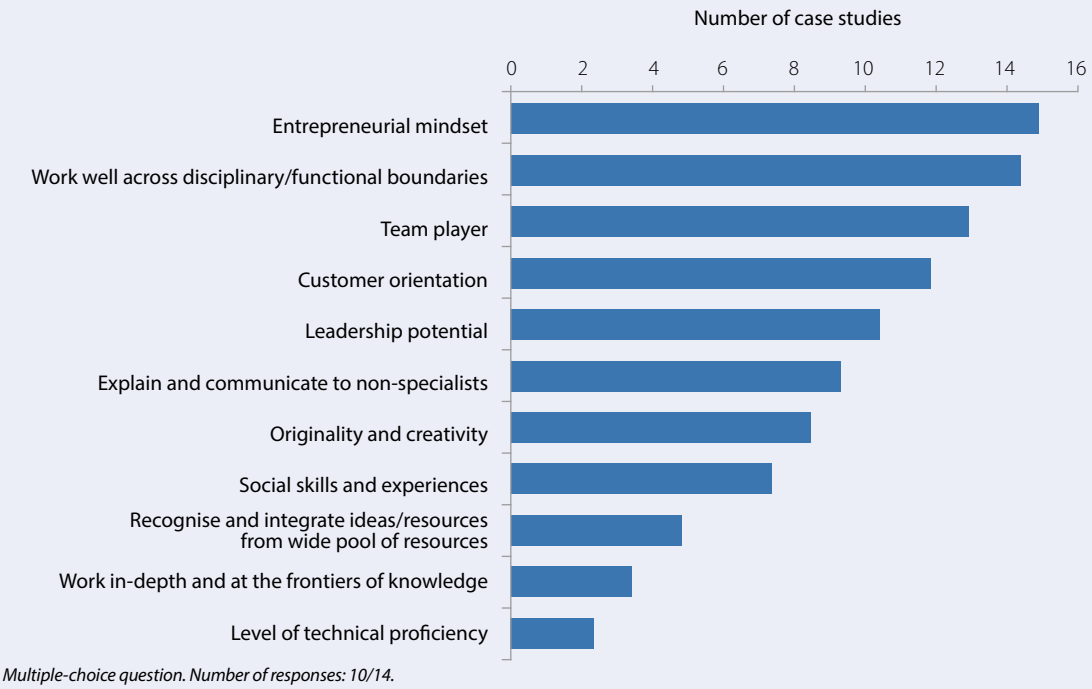
Taking a closer look at the evolution of professional profiles of doctorate holders in the company, the case studies revealed that, at the time of recruitment, the largest proportion of doctoral candidates tended to be employed as researchers (see Figure 24). However, after five to ten years in the company, doctorate holders were evenly distributed across different professional profiles, such as research, project management or line management.

The main difference in the professional profile of doctorate holders at the time of recruitment and after five to ten years in the company was the drop in the number of doctorate holders in research positions and the increase in management positions (e.g. line manager, project manager). This trend is in line with the results found in the first DOC-CAREERS project, which depicted vertical mobility as one of the main characteristics in doctoral holders' career progression.

Overall, companies were most satisfied with the quality of doctorate holders employed. The skills of doctorate holders were perceived as good or very good, specifically in relation to their scientific and technical expertise. However, occasionally the deep technical focus of doctorate holders was indicated as a weakness. For companies, the most important aspect seemed to be the balance between the deep technical focus and the breadth of knowledge of doctorate holders, coupled with an understanding of business processes and priorities. The principal areas of weakness of doctoral candidates highlighted by companies were social skills, namely difficulties in teamwork, communication or organisational skills. Low levels of knowledge of the business environment and of business processes were also mentioned as a weakness in traditional doctorate holders. However, one company also highlighted that, in their experience, doctorate holders were more successful in developing soft skills when entering the company than, for instance, Master graduates.

The companies taking part in the case studies suggested that, in order to make doctorate holders more attractive to the business sector, academic training should focus more on creating an entrepreneurial mindset, on developing interdisciplinary knowledge and on fostering social skills, namely being a team player and having a customer-focused orientation (Figure 25).

Figure 25. Skills to be further developed in university education and training for career progression in the non-academic sector



Notes: Multiple-choice question. Number of responses: 10/14.
Source: DOC-CAREERS II case studies – companies

The views of universities – Examples from case studies:

Ingolstadt University of Applied Research: *"For companies this scheme is very tempting as they are working with the candidate for several years, get to know him/her, get first-hand information and will eventually find their next co-worker (…) In addition, there is no long induction phase for the employee which saves money again and is more likely to provide immediate results."*

Newcastle University: *"The experience of undertaking research within an industrial environment and working within the constraints imposed by business equips the students to be much more aware of the drivers to take new ideas through a company. Additionally as the students are embedded within the company, they are working closely with industrial colleagues and hence it is more likely that they will be able to implement changes as a consequence of their research (…) Industry in some cases will only support Engineering Doctorate (EngD) students as it is seen as an ideal training ground for potential employees. Additionally the students are exposed to the work environment and the challenges it presents."*

University of Camerino – UNICAM Chemical: *"Based on my experience, most doctorate holders have received at the end of their doctoral programme the possibility of an employment contract in the same company."*

The views of companies – Examples from case studies:

Oryx Simulations AB: *"[We are] pleased for the moment. [Doctoral candidates] would like to see long-term challenging perspectives."*

Intel Ireland: *"[Doctorate holders from collaborative schemes] they are more experienced, [have] knowledge of industry world, built relationships."*

Alcatel Lucent: *"They make a difference from Masters, they develop soft skills adequately; managers are coming out of research."*

OCAS: *"Areas of weakness: accuracy, project management skills."*

Scandinavian Business Seating: *"Generic knowledge is missing with PhD holders – they have a very ideal mindset, not realistic. They would need to have a general knowledge of the economy and real world. [It is] hard to find a candidate that has both and not just purely academic knowledge."*

The views of doctoral candidates – Examples from case studies:

Doctoral candidate – Umeå University: *"For my plans of working in industry and for an industrial career later I believe I get a better training with the doctoral scheme compared to a standard one. Everyday is training, going to the office, talking to colleagues, meeting customers or production personnel."*

Doctoral candidate – University College London (UCL): *"Yes I do intend to work outside academia at some point in my future and see the Engineering Doctorate (EngD), with its high-level of industrial collaboration as a useful step into the bioindustry career (…) I do feel more employable because of the training courses run during the EngD and the skills I have learned from this course as opposed to more traditional programmes."*

Doctoral candidate – Newcastle University: *"I think non-academic sectors value those who have a head for business and can implement the research applicable to their company. Most PhD graduates have to be trained in a new area as their research has been too narrow and focused to be useful to the company entirely."*

4 LESSONS LEARNED AND RECOMMENDATIONS FROM STAKEHOLDERS

Collaborative doctoral schemes are becoming more widespread and there is an increasing interest in this type of partnership from universities, companies, doctoral candidates, but also from regional, national and European authorities. To build on this increasing interest and to generalise this type of partnership between universities and companies, the participants in the DOC-CAREERS II project suggested that "peer-to-peer" activities from company-to-company and university-to-university could both strengthen interest and facilitate the engagement of universities and business in collaborative doctoral schemes.

During the project it was also emphasised that there is a need to create and strengthen "communities of research", foster bridges between the academic and the business sectors, and increase awareness of the added-value of research collaborations for both universities and companies.

Drawing on their experience in establishing and taking forward collaborative doctoral programmes, the project participants outlined some key elements that can help ensure the success of these schemes and provided some recommendations for other universities and companies interested in establishing collaborative doctoral programmes. These recommendations are presented below.

Thoroughly planning the collaborative doctoral scheme, involving members from the university and the industry partner, and building trustful relationships

Planning the collaboration and defining formal agreements, especially for IPR, were deemed as extremely important aspects to ensure the success of the collaborative doctoral scheme. In this process, striking a balance between academic and business priorities and needs is essential, but the long-term goal is to develop mutual trust between the partners and to strive for sustainable relationships. By nurturing individual relationships over the years, partners come to a mutual understanding and find ways forward that do not compromise the core values and objectives of each other. During the project, all company representatives agreed on this point and highlighted that the process of clarifying goals may take several years of discussion. It was also indicated that although stakeholders may have different goals, finding common objectives is possible and desirable (e.g. common goals around employability needs).

Establishing and maintaining formal and informal contact between all the stakeholders

Ensuring the active involvement of the business partner in the scheme, in terms of funding and supervisory responsibilities, and involving the company's different hierarchical levels, including its top management representatives, were also deemed important.

Being flexible in the types/modes of collaboration

The stakeholders underlined the need to be flexible in the types/modes of collaboration, adapting them to the different size and type of businesses involved in the partnership. In this regard, the engagement of SMEs in collaborative doctoral training seems to be a particularly important point. Although partnerships with SMEs bring about mutual benefits for all the partners, these firms still face specific challenges in entering collaborative schemes, namely due to the absence, in most cases, of a person within the company that can act as a supervisor. A recommendation to help overcome this barrier is that collaborations involving joint supervision at Master's level might be easier for SMEs to engage in, as projects are of shorter duration. The need for lower financial and human resource investments of SMEs in the collaborative scheme was also indicated as a possible way forward to foster the participation of SMEs in the schemes. This would help support the development of an "R&D mindset" in the company and to build long-term mutual trust among the partners. In this respect, public funding was also deemed important in broadening the R&D culture in the companies in the private sector that were not presently enhancing their competitiveness through cutting-edge research expertise.

Ensuring the enrolment of doctoral candidates with the right skill profile

Throughout the DOC-CAREERS II project, it became apparent that the success of collaborative doctoral schemes requires a person with the right skill profile who is committed to research and at the same time, is willing to learn and bridge the academic and business culture. Universities and companies remarked that complete information on the collaborative scheme and what it entails needs to be provided before and during the doctoral candidates' application process, making clear the rights, obligations, benefits and expectations of each stakeholder. It was also indicated that academic and company supervisors could benefit from specific "peer-to-peer" training to tutor candidates involved in a collaborative doctoral scheme. Allowing doctoral candidates to participate in the choice of their doctoral research topic was considered to be important.

Developing doctoral schools

Stakeholders underlined the importance of developing doctoral schools because the consequent structuring effect is beneficial for all parties involved, as it provides guidelines and good practice examples. For instance, the case study presented by the University of Camerino (Italy) in one of the workshops showcased a doctoral school where courses were embedded in the industrial project and often required a problem-solving approach. Thus, students could learn how to discover and solve problems in real life situations and with limited time and resources, which had a positive effect on the doctoral research project itself. As another example, the case study presented by University Chieti-Pescara (Italy) showed that the doctoral school focused on generic skills and provided courses in English, EU funding and IPR issues.

Engaging in more structured dialogue between different disciplinary areas

The need for more structured dialogue between different disciplinary areas (e.g. ESSH and SET/BML) as a way to foster mutual learning about practices in different fields was also emphasised by practitioners. Discussions on collaborative doctoral programmes from different fields of knowledge could lead to a better understanding of the concepts of structure and flexibility in doctoral schemes. For example, the interdisciplinary collaborative doctoral programme CoMPLEX in University College London (UCL) involved joint supervision across UCL departments. This has allowed the development of in-house networks and the emergence of new research problems through a bottom-up process. The new fields of study emerging out of CoMPLEX's original approach attracted companies, particularly because the exploratory nature of the results simplified the negotiations on IP issues, as companies did not find an immediate interest in exploiting the results at such an early stage of development.

The views of universities – Examples from case studies:

Dublin Institute of Technology: *"It is important that all partners including business are involved in the design of the scheme from day one."*

Umeå University: *"Bottom-up process with support from management, funding 50/50 gives engagement, supervision from company."*

University College London (UCL) – BIOPROCESS: *"We have found focussing on doctoral research training around larger cohorts of students to be extremely beneficial. For the doctoral candidates involved, this approach provides improved supervisory arrangements and greater opportunities for company involvement, more opportunities to be involved with a multidisciplinary cohort and to generate a wider network of contacts. For the centre/department these larger activities provide opportunities for enhanced provision of research training, a reduction in the unit cost of training provision and enhanced opportunities for income generation either from research funding bodies or industry."*

The views of companies – Examples from case studies:

Intel Ireland: *"I think that the conference we are organising every year between the academic world and our technicians is a very good example that should be followed by other organisations."*

Jansen Pharmaceutica: *"[Need for companies to have an] entrepreneurial/exploratory spirit, bringing students into business."*

Solvay Belgium: *"Keep consistency in strategic intents and build long-term relationships (over 3 years)."*

Umicore: *"Make efforts to be open for discussion."*

5 CONCLUSIONS

The project "Promoting Collaborative Doctoral Education for Enhanced Career Opportunities" (DOC-CAREERS II) has looked at how universities work with their business and other non-university partners in establishing and taking forward research projects in the framework of doctoral education. It aimed at reflecting on good practices on university-business relations, with particular emphasis on their regional dimensions, as well as exploring the employability of doctorate holders and how collaborative schemes can enhance their career prospects. The project also engaged a variety of stakeholders from different European countries and from varied knowledge areas (Science, Engineering and Technology – SET; Biotechnology, Medical and Life Sciences – BML and; Economics, Social Sciences and Humanities – ESSH).

DOC-CAREERS II (2009-2012) builds on the first DOC-CAREERS project (2006-2009) and has sought not only to further test and validate the main results of the first project, but also to extend them by analysing the importance of the regional dimension of collaborative doctoral education and by involving universities, their business partners and doctoral candidates, with a view to collect "full stories" of the collaborative doctoral experience. These "full stories" focused on the whole breadth of aspects related to collaborative doctoral education, from its inception to the employability of doctorate holders.

The project outcomes point to the existence of a variety of collaborative models, shaped by the characteristics of the research project, the profile of the university and company and the regional context. This was apparent in aspects such as the importance of collaborative doctoral education for regional development and also for the establishment of university-business partnerships. Proximity among the different partners (e.g. geographical proximity, shared language), a common understanding of the regional context, its policies and the legal framework in place are all important elements in developing and sustaining successful partnerships. The results of DOC-CAREERS II also highlight the importance of having committed stakeholders (academic and company supervisor, doctoral candidate) with the right skill profile to take forward the collaboration. In addition, carefully planning the doctoral scheme, building trustful relations among all partners and the enhanced employability of doctorate holders who are "bilingual" in the academic and business sectors, were some of the elements of collaborative doctoral education perceived as the most relevant for stakeholders.

Specifically, the main findings emerging from the DOC-CAREERS II project can be summarised as follows:

- **Validation of DOC-CAREERS outcomes**

The new collected evidence reinforces the main messages and increases the evidence of successful collaborative doctoral programmes, both bottom-up and top-down, reported in the pioneering DOC-CAREERS project. The components[16] of collaborative doctoral programmes identified in the DOC-CAREERS project remain essential and, in particular, the involvement of a supervisor from the industry sector remains the key distinctive characteristic of these types of collaboration.

- **Regional workshops: A useful tool to foster university-industry research collaborations**

The DOC-CAREERS II project developed a valuable methodology in organising workshops that fostered and maximised fruitful discussions between all relevant practitioners and stakeholders. With the "double-acts" and "triple-acts" presentations by universities, companies and doctoral candidates, a focused and deeper dialogue was achieved. The presence of European stakeholders from other collaborative schemes demonstrated also the future potential value of "peer-to-peer" learning processes.

- **Trustful relationships**

Building and maintaining trustful relationships among all stakeholders is essential to ensure the success of the collaborative doctoral scheme. Understanding each partner's needs and objectives, establishing clear and realistic expectations and ensuring regular contact between the parties is vital to build trust and to develop long-term university-business partnerships.

- **Planning the collaborative scheme**

Planning the activities of the doctoral project well in advance and ensuring that they all make sense within the framework of the research project is a determining factor in the quality and functioning of the partnership. Involving all stakeholders in the different lifecycle stages of the scheme is also needed to ensure the success of the scheme.

- **Agreements and formal arrangements**

Comprehensive agreements between all the stakeholders should be established before the beginning of the collaborative scheme. These should include the rights and obligations of each party, general rules for the collaboration, financial provisions and intellectual property ownership and rights. IPR should be negotiated from the outset, with a view to balance the interests of all stakeholders in relation to the publication and potential commercial application of the research results.

[16] The components of collaborative doctoral programmes include: strategic level of engagement in the organisation (university and business); roles of industrial partners; selection of the doctoral research topic, additional admission requirements for doctoral candidates; formal agreements and general conditions; legal status of the doctoral candidate and; supervisory scheme. Please refer to Borrell-Damian, L., 2009, *Collaborative Doctoral Education. University-Industry Partnerships for Enhancing Knowledge Exchange. DOC-CAREERS Project* (Brussels, EUA).

- **Supervision**

Although the academic supervisor is ultimately responsible for ensuring that the doctoral research project is of the required academic quality to earn a doctoral degree, the industrial/business supervisor is an integral and core part of the collaborative scheme. Project participants agreed that the company supervisor should hold a doctorate degree him/herself or, alternatively, should be keenly aware of what doctoral research entails. Academic and business supervisors could also benefit from "peer-to-peer" training for tutoring doctoral candidates involved in collaborative schemes.

- **The "right people" skill profile**

Taking part in a collaborative doctoral scheme requires a specific skill profile. Doctoral candidates should not only be committed to research, but should also be willing to develop their work in an industrial setting, making compatible two worlds – academia and business. Academic and company supervisors should understand each other's needs and priorities and be committed to take the partnership forward while ensuring the quality of the doctoral degree.

- **Diversity of collaborative models**

There is no "one-size fits all" model for collaborative doctoral training. Instead, the outcomes of the project have shown a variety of successful models, emerging from both top-down and bottom-up levels. The key factor seems to be the involvement of all hierarchical levels and, particularly, the support of the top management, both in universities and in companies.

- **Employment in the non-academic sector**

All stakeholders agreed that doctorate holders from collaborative schemes are more employable in the non-academic sector than doctorate holders from traditional programmes. The ability to be "bilingual", bridging the academic and business sectors, and the development of transferable skills, were identified by the stakeholders as the main reasons accounting for the better employment prospects for doctorate holders in the non-academic sector.

- **Interdisciplinary dialogue**

Project participants identified the importance of the need for more dialogue between the SET, BML and ESSH fields. Closer linkages between the different scientific fields are beneficial to foster mutual learning and to share good practice examples.

- **The specificity of SMEs**

SMEs face specific challenges in engaging in collaborative doctoral programmes (e.g. absence of someone to act as industrial supervisor, funding difficulties). To overcome some of these difficulties, project participants have suggested that SMEs could engage in joint supervision at Master's level, as these projects are of shorter time duration. The need to develop collaborative schemes that require a low-level of investment from SMEs was also suggested. In this vein, public funding, national or European, for collaborative doctoral schemes seems essential to develop the R&D culture in SMEs.

- **Overcoming barriers to collaborative doctoral education**

To overcome some reluctance on the part of academics and companies to engage in a collaborative doctoral schemes, "peer-to-peer" activities from company-to-company and from university-to-university could be used to change some existing stereotypes and to develop a more positive outlook towards university-business collaboration, with a view to bring more partners into such collaborations.

- **Public support**

Participants mentioned public support as an essential component of collaborative research. Public support includes not only funding, but also adequate policies and legislation to encourage university-business partnership. In this respect, special attention should be paid to reward mechanisms for university researchers involved in collaborations and the establishment of legal frameworks that support both universities and businesses in protecting and recognising their different purposes and missions. Fostering collaboration where mutual interests are identified was also regarded as a crucial aspect that needs to be addressed.

- **The regional dimension**

All university-business partnerships in DOC-CAREERS II had a strong local base. While all partnerships consistently met the characteristics of the seven main components of collaborative doctoral research (identified in DOC-CAREERS, 2009), these collaborative doctoral agreements were successful because of a deep understanding of the regional business/industry dynamics and local/regional/national legal framework shared by the partners.

- **The policy dimension**

Throughout the project, it became clear that regions that sought to build their competitiveness through innovation from university R&D did indeed value collaborative doctoral programmes and the skills that doctoral candidates acquire through their education and training. These regions establish policies that support research collaborations and commit resources through local/regional public programmes and encourage the participation of local SMEs. Some of these regions also encourage applications for funding from European and worldwide competitive calls and push for mobilising private funding.

The DOC-CAREERS II project aimed to contribute to the development and improvement of institutional, regional, national and European codes of practice in collaborative doctoral education, highlighting good practice examples and providing a support network to facilitate university-business collaboration. It has promoted long-term university-business collaboration and has proven its value by highlighting the benefits for all stakeholders involved: university, businesses and doctoral candidates. In addition, DOC-CAREERS II has further highlighted the value of the exposure of the doctoral candidate to both the academic and business sector, and the consequent benefits for individuals pursuing an inter-sectoral career. Overall, it is felt that for all organisations (both public and private) whose development strategies involve medium to long-term R&D investments the value of such doctorate holders has been demonstrated through the empirical evidence gathered in the project.

We hope, therefore, that the outcomes of the DOC-CAREERS II project can further stimulate discussions among universities, companies, regional, national and European authorities on university-business partnerships in general, and collaborative doctoral schemes in particular. Finally, we hope that these

project findings can be a valuable resource of best practices for all relevant stakeholders and that they can spark the interest of the academic and the business communities to engage in, and further consolidate, research collaborations in doctoral education.

ANNEX 1

LIST OF CONTRIBUTING ORGANISATIONS: UNIVERSITIES, COMPANIES AND OTHER STAKEHOLDERS

The following list includes the organisations that were actively involved in the DOC-CAREERS II project. These organisations are classified in three groups: higher education institutions, companies, and other organisations. All the organisations listed below contributed valuably to the outcomes of the project.

The roles of the organisations in the DOC-CAREERS II project are shown in brackets, according to the following categories:

- Case study – questionnaire: organisations that answered an in-depth structured questionnaire;
- Case study – workshop: organisations that presented their case study in the workshop(s);
- Workshop participants: organisations that participated in the workshops, but did not present a specific case study;
- Steering Committee members.

Higher Education Institutions

1. Ghent University, Belgium (1 university case study – questionnaire [Baekeland initiative IWT], 6 doctoral candidates case studies, case study – workshop)
2. Hanken School of Economics, Finland (case study – workshop)
3. University Pierre and Marie Curie, France (workshop participant)
4. Ingolstadt University of Applied Research, Germany (1 university case study – questionnaire)
5. University of Paderborn, Germany (workshop participant, Steering Committee)
6. Dublin Institute of Technology, Ireland (2 university case studies – questionnaires [Environmental Health Sciences, EHS; Graduate Programme in Creative Arts and Media, GradCAM], case study – workshop)
7. Dun Laoghaire Institute of Art, Design and Technology, Ireland (case study – workshop)
8. National College of Art and Design, Ireland (case study – workshop)
9. National University of Ireland, Galway, Ireland (workshop participant)
10. University College Cork, Ireland (workshop participant)
11. University College Dublin, Ireland (workshop participant)

12. Polytechnic University of Marche, Italy (workshop participant)
13. Polytechnic University of Milan, Italy (workshop participant)
14. University of Camerino, Italy (2 university case studies – questionnaires [Chemical and Pharmaceutical Sciences, UNICAM Chemical; PhD Programme on Malaria and Human Development, UNICAM Malaria], case study – workshop)
15. University of Chieti-Pescara, Italy (case study – workshop)
16. University of Ferrara, Italy (1 university case study – questionnaire [Pharmaceutical Sciences], case study – workshop)
17. University of Perugia, Italy (1 university case study – questionnaire [Animal Health, Livestock Production and Food Safety], 1 doctoral candidate case study, case study – workshop)
18. Kaunas University of Technology, Lithuania (1 university case study – questionnaire, case study – workshop, Steering Committee)
19. Klaipeda University, Lithuania (workshop participant)
20. Lithuanian University of Agriculture, Lithuania (workshop participant)
21. Lithuanian University of Health Sciences, Lithuania (case study – workshop)
22. Mikolas Romeris University, Lithuania (workshop participant)
23. Siauliai University, Lithuania (workshop participant)
24. Vilnius Gediminas Technical University, Lithuania (case study – workshop)
25. Norwegian University of Science and Technology (NTNU), Norway (2 university case studies – questionnaires [standard PhD programme; Industrial PhD scheme], 5 doctoral candidates case studies, case study – workshop)
26. Pompeu Fabra University, Spain (workshop participant, Steering Committee)
27. Rovira i Virgili University, Spain (workshop participant)
28. Umeå University, Sweden (1 university case study – questionnaire [Industrial Graduate School for Research and Innovation, IGS], 3 doctoral candidates case studies, case study – workshop)
29. École Polytechnique Fédérale de Lausanne (EPFL), Switzerland (1 university case study – questionnaire, case study – workshop)
30. Swiss Federal Institute of Technology Zurich (ETH), Switzerland (workshop participant)
31. Bangor University, United Kingdom (1 university case study – questionnaire [Knowledge Economy Skills Scholarships, KESS], case study – workshop, Steering Committee)
32. Newcastle University, United Kingdom (1 university case study – questionnaire [Engineering Doctorate Biopharmaceutical Process Development], 3 doctoral candidates case studies, case study – workshop)
33. University College London, United Kingdom (3 university case studies – questionnaire [Security Science Doctoral Research Training Centre, UCL SECReT; Bioprocess Engineering Leadership, UCL Bioprocess; Centre for Mathematics and Physics in the Life Sciences and Experimental Biology, UCL CoMPLEX], 3 doctoral candidates case studies, case study – workshop)
34. University of Ulster, United Kingdom (workshop participant)

Companies

1. Alcatel Lucent, Belgium (case study – questionnaire)
2. Applied Maths, Belgium (workshop participant)
3. Solvay S.A. Research and Technology, Belgium (case study – questionnaire, Steering Committee)
4. GlaxoSmithKline Biologicals (GSK Biologicals), Belgium (case study – questionnaire)
5. Jansen Pharmaceutica, Belgium (case study – questionnaire)
6. OCAS, Belgium (case study – questionnaire)
7. Umicore, Belgium (case study – questionnaire, case study – workshop)
8. Genes Diffusion, France (case study – workshop)
9. Schlumberger, France (case study – questionnaire)
10. Biotalentum, Hungary (case study – questionnaire)
11. Intel, Ireland (case study – questionnaire)
12. Advanced Technologie Biomagnetic s.r.l., Italy (workshop participant)
13. Aptuit, Italy (case study – workshop)
14. Finmeccanica, Italy (workshop participant)
15. Goldenplast s.p.a., Italy (case study – workshop)
16. iGuzzini Illuminazione s.p.a., Italy (workshop participant)
17. Oncoxx Biotech S.r.l., Italy (case study – workshop)
18. SINERGO s.r.l., Italy (workshop participant)
19. Comfort Heat UAB, Lithuania (case study – workshop)
20. Lithuanian Energy Institute, Lithuania (workshop participant)
21. Naujasis Nevėžis UAB, Lithuania (case study – workshop)
22. Det Norske Veritas (DNV), Norway (workshop participant)
23. Farsund Aluminium Casting, Norway (case study – questionnaire)
24. Nord-Trøndelag Elektrisitetsverk AS (NTE), Norway (case study – workshop)
25. Ortivio, Norway (case study – questionnaire)
26. Scandinavian Business Seating, Norway (case study – questionnaire)
27. The Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology (SINTEF), Norway (case study – workshop)
28. Skretting, Norway (case study – questionnaire)
29. Statoil, Norway (case study – workshop)
30. Domsjö Fabriker AB, Sweden (case study – workshop)
31. Oryx Simulations AB, Sweden (case study – questionnaire)

32. Debiotech SA, Switzerland (case study – workshop)
33. Helbing Technik Bern AG, Switzerland (case study – workshop)
34. Rolex SA, Switzerland (case study – workshop)
35. Sonceboz Automotive SA, Switzerland (case study – workshop)
36. Biopharmaceutical Bioprocessing Technology Centre, United Kingdom (case study – workshop)

Other organisations

1. EURODOC, Belgium (workshop participant)
2. European Commission, DG Education and Culture, Marie Curie Actions Unit, Belgium (final conference participant)
3. European Commission, DG Research & Innovation, Belgium (workshop participant, Steering Committee)
4. European Industrial Research Management Association, Belgium (workshop participant, Steering Committee)
5. European University Association, Belgium (workshop participant, steering committee)
6. Dublin City Council, Ireland (case study – workshop)
7. Health Service Executive, Ireland (case study – workshop)
8. Higher Education Authority, Ireland (workshop participant)
9. Irish Universities Association, Ireland (workshop participant)
10. Confindustria Young Entrepreneurs, Italy (workshop participant)
11. Council for Industrial Development, Marche region, Italy (workshop participant)
12. Italian Ministry of Education University and Research, Italy (workshop participant)
13. Ministry of Education and Science, Lithuania (workshop participant)
14. Association of Doctoral Organisations in Norway, Norway (workshop participant)
15. NIFU STEP – Studies in Innovation, Research and Education, Norway (workshop participant)
16. Nordic Institute for Studies in Innovation, Education and Research, Norway (workshop participant)
17. Research Council of Norway, Norway (workshop participant)
18. The Association of Norwegian Research Institutes, Norway (workshop participant)
19. The Norwegian Association of Higher Education Institutions, Norway (workshop participant)
20. Fundación Universidad-Empresa, Spain (workshop participant)
21. Rectors' Conference of the Swiss Universities, Switzerland (workshop participant)
22. World Health Organisation, Switzerland (case study – workshop)
23. Vitae, United Kingdom (workshop participant)

The following countries were represented in the workshops, case studies – questionnaires and in the final conference:

1. Belgium
2. Finland
3. France
4. Germany
5. Hungary
6. Ireland
7. Italy
8. Lithuania
9. Norway
10. Spain
11. Sweden
12. Switzerland
13. United Kingdom

LIST OF PUBLICLY PRESENTED CASE STUDIES IN DOC-CAREERS II

The following table presents a list of the case studies publicly presented in the DOC-CAREERS II workshops. Please note that additional presentations by the workshops host universities and other key stakeholders in the project are available at:
http://www.eua.be/eua-work-and-policy-area/research-and-innovation/doctoral-education/doc-careers-ii.aspx

Organisation(s) in a case study	Country	Name of doctoral scheme (if applicable)	Presenter(s)	Link for further information
Ghent University	Belgium	Baekeland Initiative (IWT)	Dr Nele Bracke Koen Janssens	http://www.eua.be/Libraries/Doc-Careers/Bracke_UGent.sflb.ashx http://www.eua.be/Libraries/Doc-Careers/Janssens_UGent.sflb.ashx
Umicore Group R&D	Belgium		Prof. Egbert Lox	http://www.eua.be/Libraries/Doc-Careers/LoxUmicore-final.sflb.ashx
European Doctoral Programmes Association in Management and Business Administration Hanken School of Economics	Finland		Prof. Maj-Britt Hedvall	http://www.eua.be/Libraries/Doc-Careers/Prof_Maj-Britt_Hedvall_Doc-Careers__050411.sflb.ashx
Dublin Institute of Technology Health Service Executive Dublin City Council	Ireland	Environmental Health Sciences Institute	Prof. Mary McNamara	http://www.eua.be/Libraries/Doc-Careers/Dr_Mary_McNamara_-_DIT.sflb.ashx
Dublin Institute of Technology National College of Art and Design Dun Laoghaire Institute of Art, Design and Technology	Ireland	GradCAM (Graduate School of Creative Arts & Media)	Dr Mick Wilson Conor McGarrigle Dr Nollaig Ó Fiongháile	http://www.eua.be/Libraries/Doc-Careers/Gradcam.sflb.ashx
Health Service Executive	Ireland		Martin Devine	http://www.eua.be/Libraries/Doc-Careers/Martin_Devine_-_Health_Service_Executive.sflb.ashx
Dublin Institute of Technology Health Service Executive	Ireland		Dr Sharon Kennelly	http://www.eua.be/Libraries/Doc-Careers/Sharon_Kennelly_-_DIT.sflb.ashx
University of Chieti-Pescara Oncoxx S.r.l	Italy		Prof. Mario Bressan Dr Saverio Alberti Dr Simona Tecco	http://www.eua.be/Libraries/Doc-Careers/Group_A_-_Chieti-Pescara_Prof_Mario_Bressan.sflb.ashx http://www.eua.be/Libraries/Doc-Careers/Group_A_-_Chieti-Pescara_Dr_Saverio_Alberti.sflb.ashx
University of Camerino Goldenplast s.p.a	Italy	PhD Programme in Chemical and Pharmaceutical Sciences	Prof. Enrico Marcantoni Dr Roberto Fiocchi Gian Carlo Bagaglio	http://www.eua.be/Libraries/Doc-Careers/Group_A_-_University_of_Camerino_Footwear_of_Excellence_Prof_Enrico_Marcantoni.sflb.ashx http://www.eua.be/Libraries/Doc-Careers/Group_A_-_Univeristy_of_Camerino_Footwear_of_Excellence_Roberto_Fiocchi.sflb.ashx http://www.eua.be/Libraries/Doc-Careers/Group_A_-_University_of_Camerino_Footwear_of_excellence_Gian_Carlo_Bagaglio.sflb.ashx
University of Camerino World Health Organization	Italy Switzerland	PhD Programme on Malaria and Human Development	Dr Annette Habluetzel Dr Roselyne Nzangue Tepongning Dr Pascal Launois	http://www.eua.be/Libraries/Doc-Careers/Group_C_-_PhD_Programme_on_Malaria_and_human_Development_UNICAM_and_WHO_All_presenters_in_one.sflb.ashx
University of Perugia Genes Diffusion	Italy France	PhD programme on Animal Health, Production and Food Safety	Prof. Maurizio Monaci Claudio Palombi Christophe Rouseré	http://www.eua.be/Libraries/Doc-Careers/Group_B_-_University_of_Perugia_case_Prof_Mauricio_Monaci_Claudio_Palombi_Cristophe_Rouser%c3%a9.sflb.ashx

Organisation(s) in a case study	Country	Name of doctoral scheme (if applicable)	Presenter(s)	Link for further information
University of Ferrara Aptuit	Italy	PhD Programme in Pharmaceutical Sciences	Prof. Stefano Manfredini Dr Carmela Napolitano Dr Alfredo Paio	http://www.eua.be/Libraries/Doc-Careers/Group_C_-_University_of_Ferrara_Together_To_Compete_All_presenters_in_one.sflb.ashx http://www.eua.be/Libraries/DOC-CAREERSII_Brussels_event/Napolitano.sflb.ashx
Vilnius Gediminas Technical University	Lithuania		Prof. Raimundas Kirvaitis	http://www.eua.be/Libraries/Doc-Careers/Prof_Raimundas_Kirvaitis_DOC-CAREERS_II_Kaunas.sflb.ashx
Lithuanian University of Health Sciences	Lithuania		Prof. Vaiva Lesauskaite	http://www.eua.be/Libraries/Doc-Careers/Prof_Vaiva_Lesauskaite_presentation_04_04.sflb.ashx
Kaunas University of Technology Comfort Heat UAB Naujasis Nevezis UAB	Lithuania		Prof. Rymantas Kazys Dr Vyda Mozuriunienė Dr Rasa Svobuné	http://www.eua.be/Libraries/DOC-CAREERSII_Brussels_event/Rymantas_Kazys.sflb.ashx http://www.eua.be/Libraries/DOC-CAREERSII_Brussels_event/Vyda_Mozuriuniene_presentation_DOC-CARERRS_II_Final_sesion.sflb.ashx http://www.eua.be/Libraries/DOC-CAREERSII_Brussels_event/RASA_Svobune.sflb.ashx http://www.eua.be/Libraries/Doc-Careers/Dr_Rasa_Svobune_Kaunas_conference_2011_04_05.sflb.ashx
Norwegian University of Science and Technology (NTNU) Nord-Trøndelag Elektrisitetsverk AS (NTE)	Norway		Prof. Ingval Strømmen Erling Tønne Dr Jan Foosnæs	http://www.eua.be/Libraries/Doc-Careers/Prof_Ingvald_Str%C3%B8mmen.sflb.ashx http://www.eua.be/Libraries/Doc-Careers/Erling_Tonne.sflb.ashx http://www.eua.be/Libraries/Doc-Careers/Dr_Jan_Foosnaes.sflb.ashx
Norwegian University of Science and Technology (NTNU) The Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology (SINTEF)	Norway		Prof. Asbjørn Rolstadås Linda Hald	http://www.eua.be/Libraries/Doc-Careers/Linda_Hald_and_Prof_Asbj%C3%B8rn_Rolstadas_1.sflb.ashx
Norwegian University of Science and Technology (NTNU) STATOIL	Norway		Prof. Børge Arntsen Kenneth Duffaut Dr Lasse Amundsen	http://www.eua.be/Libraries/Doc-Careers/Prof_B%c3%b8rge_Arntsen_Kenneth_Duffaut_Dr_Lasse_Amundsen.sflb.ashx
Umeå University Domsjö Fabriker AB	Sweden	Industrial Graduate School	Prof. Petter Gustafsoon Dr Kristina Elg Christoffersson Peter Strunk	http://www.eua.be/Libraries/Doc-Careers/Umea.sflb.ashx
Umeå University Bangor University	Sweden United Kingdom	The European Industrial Doctoral School*	Prof. Petter Gustafsson Prof. David Shepherd	http://www.eua.be/Libraries/DOC-CAREERSII_Brussels_event/European_Industrial_Doctoral_School.sflb.ashx http://www.eua.be/Libraries/DOC-CAREERSII_Brussels_event/European_Industrial_Doctoral_School.sflb.ashx
École Polytechnique Fédérale de Lausanne (EPFL)	Switzerland		Prof. Patrick Aebischer	http://www.eua.be/Libraries/Doc-Careers/Aebischer_EPFL.sflb.ashx
École Polytechnique Fédérale de Lausanne (EPFL) Sonceboz	Switzerland		Dr Marc-Olivier André	http://www.eua.be/Libraries/Doc-Careers/Andre_Sonceboz.sflb.ashx
Centre de Recherches en Physique des Plasmas (EPFL)	Switzerland		Dr Christoff Hollestein	http://www.eua.be/Libraries/Doc-Careers/Hollenstein_EPFL.sflb.ashx
Helbling Technik Bern aG	Switzerland		Dr Christian Peclat	http://www.eua.be/Libraries/Doc-Careers/Peclat_Helbling.sflb.ashx

Organisation(s) in a case study	Country	Name of doctoral scheme (if applicable)	Presenter(s)	Link for further information
Laboratoire de simulation des matériaux (LSMX; EPFL)	Switzerland		Prof. Michel Rappaz	http://www.eua.be/Libraries/Doc-Careers/Rappaz_EPFL.sflb.ashx
École Polytechnique Fédérale de Lausanne (EPFL) Rolex	Switzerland		Dr Jacques Baur	http://www.eua.be/Libraries/Doc-Careers/Baur_Rolex.sflb.ashx
École Polytechnique Fédérale de Lausanne (EPFL) Debiotech SA	Switzerland		Prof. Jacques Giovanola Dr Laurent-Dominique Piveteau	http://www.eua.be/Libraries/DOC-CAREERSII_Brussels_event/Giovanola.sflb.ashx http://www.eua.be/Libraries/DOC-CAREERSII_Brussels_event/L-D_Piveteau_EUA20120130.sflb.ashx
Newcastle University Biopharmaceutical Bioprocessing Technology Centre	United Kingdom	EngD Bio-pharmaceutical Process Development	Prof. Elaine Martin Jodie A. Symington	http://www.eua.be/Libraries/Doc-Careers/Prof_Elaine_Martin_-_Newcastle_University.sflb.ashx
Bangor University	United Kingdom	KESS (Knowledge Economy Skills Scholarship)	Dr Bryn Jones	http://www.eua.be/Libraries/Doc-Careers/Dr_Bryn_Jones_-_KESS_case_Kaunas_DOC-CAREERS_II.sflb.ashx
University College London	United Kingdom	CoMPLEX (The Centre for Mathematics and Physics in the Life sciences and Experimental biology)	Prof. Alan Johnston Gwenan Knight	http://www.eua.be/Libraries/Doc-Careers/Prof_Alan_Johnston.sflb.ashx http://www.eua.be/Libraries/Doc-Careers/Gwenan_Knight.sflb.ashx
University College London	United Kingdom	SECReT (Security Science Doctoral Research Training Centre)	Prof. Herve Borrion Timothy H. Nissen	http://www.eua.be/Libraries/Doc-Careers/Group_B_-_SECReT_Case_Prof_Herv%c3%a9_Borrion_Tim_Nissen.sflb.ashx

Note (*): The European Industrial Doctoral School (E.I.D.S.) was initiated and first presented at the DOC-CAREERS II final conference in Brussels in January 2012. The E.I.D.S. is composed of the following institutions: Umeå University (Sweden), Bangor University (United Kingdom), Ghent University (Belgium), University of Pardubice (Czech Republic) and University of Aveiro (Portugal). This partnership aims at tackling societal challenges through collaborative doctoral education and focuses on soft skills training, giving opportunities to doctoral candidates from a variety of scientific and geographic areas to grow and develop as researchers.

ANNEX 2

DOC-CAREERS II STEERING COMMITTEE MEMBERS

The DOC-CAREERS II Steering Committee members provided guidance to the project development and contributed valuably to its success. The complete list of Steering Committee members is provided below.

- Dr David Joyner – Director of Business Partnership and Engagement Research and Innovation Office, Bangor University (United Kingdom);
- Prof. Eckhard Steffen – Director of Graduate Studies, University of Paderborn (Germany);
- Dr Leopold Demiddeleer – former President of the European Industrial Research Management Association (EIRMA), former Future Businesses Director, Solvay S.A. Research & Technology (Belgium);
- Prof. María Morrás Ruíz-Falcó – EUA-Council for Doctoral Education (CDE) Board Member; Vice-Rector for International Relations, Pompeu Fabra University (Spain);
- Prof. Rymantas Kažys – Vice-Rector for Research, Kaunas University of Technology (Lithuania).

The European University Association (EUA) is the representative organisation of universities and national rectors' conferences in 47 European countries. EUA plays a crucial role in the Bologna Process and in influencing EU policies on higher education, research and innovation. Thanks to its interaction with a range of other European and international organisations EUA ensures that the independent voice of European universities is heard wherever decisions are being taken that will impact on their activities.

The Association provides a unique expertise in higher education and research as well as a forum for exchange of ideas and good practice among universities. The results of EUA's work are made available to members and stakeholders through conferences, seminars, website and publications.

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