UNIVERSITY RESEARCHERS' COLLABORATION WITH INDUSTRY AND THE PUBLIC SECTOR

– A SURVEY OF UNIVERSITY RESEARCHERS IN DENMARK

VI FREMMER VIDEN

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A background report in the form of an Excel spreadsheet is available for download from DEA's webpage (www.dea.nu/survey-of-university-researchers).

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PREFACE

Fruitful interaction between universities and business or public sector organizations is a key driver of innovation. For that reason, strengthening knowledge exchanges between universities and their surrounding communities is highlighted as one of three major paths to growth and job creation in the Danish government's national innovation strategy, *Denmark – a nation of solutions*.

Much emphasis is placed today on supporting academic researchers in their interplay with private or public collaborators, for example by establishing technology transfer offices, providing legal support, and developing university or faculty-wide strategies and initiatives. While such efforts are important, university-industry collaboration is – to a large extent – the result of individual researchers' decision to invest resources in building and maintaining ties to firms, public institutions or other non-academic organizations.

In 2013, DEA published a qualitative study of technology transfer activities at Danish universities. A key finding of the study was that we lack systematic insight into the extent and nature of non-academic collaboration among researchers employed at Danish universities.

The aim of this survey of university researchers' collaboration with industry and the public sector has been to remedy this lack, by providing micro level insight into individual researchers' collaboration experience, motivations and outcomes that can help pave the way for more informed policies to stimulate the university-industry knowledge exchange.

We would like to thank the seven Danish universities who made this survey possible by allowing us to contact their researchers. We hope that the universities will allow us to repeat this survey every few years, as it would be valuable to track the development of the extent of researchers' non-academic collaboration and their perceptions of the outcomes and barriers of such collaboration.

We would also like to thank the Danish Agency for Science, Technology and Innovation for providing financial support for the study. Moreover, we received invaluable feedback from the Universities Denmark's InnoTech-group on innovation and technology transfer.

Most importantly, we would like to thank the thousands of university researchers who took the time to complete the survey and provide us with greater insight into the motivations and barriers affecting their everyday decisions to engage with the surrounding society.

Stina Vrang Elias
Adm. direktør, DEA

INTRODUCTION AND KEY FINDINGS

Through much of the twentieth century, universities were primarily expected to deliver two things in return for the public funding they receive: to produce well-educated graduates and to undertake and disseminate research. Today, universities are also expected to fulfill a so-called "third mission" to stimulate a greater awareness and exploitation of university research outside academia.[1]

These "third mission" activities cover a broad range of mechanisms for interacting with the non-academic world, from engaging in dialogue with civil society to setting up spin-out companies dedicated to the commercial development and application of university research.

There is nothing new about universities working together with the private sector or public sector.[2] In fact, direct interaction between universities and their surrounding environment has played an important role during several previous periods in the evolution of the university.[3] What *has* changed in recent decades, however, is the increased focus on the short-term effects and commercial exploitation of university research.

The current push for more direct value creation from university research emerged in the U.S. during the 1970s, then subsequently spread across the globe. It arose as a result of policymakers' growing dissatisfaction with the measurable outputs of university research, coupled with a growing concern regarding the U.S.' competitiveness and innovativeness vis-à-vis emerging economies in Asia.[4]

Policymakers today remain under pressure to show that the substantial public investments in university research yield a measurable pay-off in the private sector, e.g. in the form of innovative products, successful new science-based companies, and increased knowledge and technology intensive exports. Policymakers across the world, including in Denmark, have therefore focused extensively on boosting universities' direct collaboration with the private and public sector, the establishment of university spin-out companies, and the sale or licensing of university-owned intellectual property rights.[5]

The value of universities' "third mission" activities is often reduced to what we can measure using indicators such as the number (or financial value) of collaborations with industry and the number of invention disclosures, granted university patents, licensing agreements, spin-out companies etc. Yet academic research has shown that measurable outputs such as patenting account for just a small fraction of the total transfer of knowledge that occurs between academia and the private sector.[6] Formal knowledge exchanges between universities and industry do not emerge out of the blue, but can instead better be described as by-products of personal and often long-lasting relationships between academics and their contacts in the public or private sector. These relationships can involve a broad variety of mechanisms for interaction, many of which are difficult or impractical to document or estimate the value of, including e.g. collaboration on teaching, consulting and even informal dialogue.[7]

Moreover, the current focus on quantitative indicators related to publicly co-funded R&D collaborations, patenting, and spin-out companies are likely to be biased towards the so-called "hard sciences" where such mechanisms are far more common than in the "soft sciences". Recent research shows that the social sciences and humanities rely more heavily than the hard sciences on consulting and contract research as mechanisms for engaging with non-academic partners.[8] These mechanisms are, however, often not systematically registered, which may lead to an underestimation of the extent of collaboration that takes place between the soft sciences and the non-academic sector.

In addition, the current focus on quantitative indicators favors *formal mechanisms* for collaboration and may therefore lead to an underemphasis on the importance of *informal mechanisms* for collaboration, *collaboration on teaching* and *personal relationships*, all of which often play a key role in building strong, trust-based collaborative relationships from which instances of formal collaboration can emerge.

The current focus on aggregate indicators of "third mission" activities has another key limitation: it implicitly treats academic researchers as a homogenous group, which they are not. Engaging in collaboration with non-academic partners or working actively to promote the commercial development of scientific research is, to a large extent, an individual decision. Each researcher must continuously decide how to allocate his or her time to the pursuit of various (sometimes complementary, sometimes competing) activities, including undertaking research, attracting funding for research, teaching, doing administrative work, engaging in non-academic collaboration and disseminating research to non-academic audiences.[9]

To develop effective policies aimed at strengthening "third mission" activities in universities, both policymakers and university managers therefore need greater insight into how individual scientists engage in collaboration and commercialization activities as well as into the actual nature of these activities.

Such data is available from other countries,[10] but has not previously been collected systematically among Danish researchers. The aim of the survey presented in this report was to collect such data.

1. ABOUT THE SURVEY

This report presents the findings of an online survey conducted among all full-time researchers[11] in seven of the eight Danish universities.[12]

The aim of the survey was to investigate the *extent of collaboration* between researchers and the public and private sector, the nature of the *collaboration mechanisms* involved, and researchers' perceptions of the *motivations* for,

1. See e.g. Branscomb et al. 1999; Etzkowitz & Leydesdorff 1997, 2000; Etzkowitz et al. 2000.
2. See e.g. Lee 1996; Rosenberg and Nelson 1994; Tether 2002.
3. See Martin 2003 for a discussion of the historical development of the social contract between universities and society.
4. See e.g. Pavitt 1991, 2001.
5. See e.g. Nelson 2004, 2006.
6. Agrawal & Henderson 2002.
7. See e.g. D'Este & Patel 2007; Perkmann & Walsh
8. Olmos-Peñuela et al. 2014.
9. See e.g. Davis et al. 2011 and Tartari & Breschi 2012.
10. For a review of studies, see e.g. Geuna & Nesta 2006; Larsen 2011; Perkmann et al. 2013.
11. The survey population included all scientific staff members including PhD students and postdocs. As far as possible, research assistants and staff employed solely to undertake teaching activities were excluded.
12. The University of Southern Denmark declined to participate in the study.

outcomes of and *barriers* to such collaboration.

In the following, some key findings and implications of the survey are presented. For more detailed information about the survey or the survey results, please consult the subsequent chapters of this report. For data on variations in the survey results across e.g. universities, scientific disciplines, and respondents' academic rank, background data in the form of an Excel spreadsheet is available for download from DEA's webpage (www.dea.nu/survey-of-university-researchers).

2. WHO PARTICIPATED IN THE SURVEY?

An invitation to participate in the survey was sent to 13,428 researchers by email. Invitations to 987 researchers never reached their recipient, as the email invitations could not be delivered (presumably due to mistakes in the email addresses, full mailboxes and the like, bringing the actual survey population to 12,441. 3,272 university researchers completed the survey on their engagement with industry and the public sector, giving a response rate of 26 pct.

Response rates were roughly similar at the participating universities, ranging from 21 to 28 pct.[13]

Two thirds of the respondents are Danish. 54 pct. of the respondents who have another nationality than Danish are PhDs or postdocs, compared to just 29 pct. of the Danish respondents.

Survey responses reveal that three out of every four respondents have engaged with the non-academic sector in the past three years. There is however substantial variation across the participating universities. For example, while 86 and 85 pct. of respondents from AAU and CBS, respectively, have interacted with the non-academic sector, this is true for just 66 pct. of respondents from KU.

More detailed analysis of survey responses also reveals substantial variation across disciplines and that non-academic collaboration is more common among senior researchers than junior researchers. The latter finding is not surprising, given that senior researchers are likely to be more visible and attractive partners to industry because of their academic experience and track record. They are also likely to have larger networks outside academia.[14]

A comparison between the respondents and the total population of university researchers in Denmark reveals that the survey respondents are highly representative of the national population of researchers as distributed by gender, university and scientific discipline, save for a slight overrepresentation of social scientists and a slight underrepresentation of health scientists among the survey respondents. The proportion of junior researchers (here defined as PhD students and postdocs) is underrepresented in the group of survey respondents compared to the national total, where PhD students account for the majority of university researchers. This is, however, not a disadvantage to the survey, as senior researchers are likely to have more collaborative experience on which to base their responses.

It is important to stress that we have no way of determining how representative survey respondents are of the total population of university researchers when it comes to engagement with the non-academic world. It is probable that researchers who have experience collaborating with industry were more likely to participate in the survey than researchers who have little or no such experience, but we cannot say anything for certain about the nature or extent of non-respondents' collaborations.

It is worth noting, though, that the vast majority of survey respondents work in research units or departments where interaction with non-academic organizations is "very" or "somewhat" common. This suggests that researchers who contributed to the survey work in environments where non-academic collaboration is a part of everyday academic life, regardless of whether the respondents themselves engage in such collaboration. This may have been a factor in their decision to fill out the survey.

3. WHAT TYPES OF COLLABORATION DO RESEARCHERS ENGAGE IN?

This section focuses solely on the 75 pct. of respondents who have engaged in some degree of non-academic collaboration within the past three years, and describes the nature of that collaboration.

Almost half the respondents from the hard sciences have engaged in *patenting activities* in the past three years. In addition, one in every five university respondents has helped *start a company* based on their research at some point in their academic career. The percentage of respondents, who have started one or more companies, is similar for all universities and all scientific disciplines, including the social sciences and the humanities. There appear, however, to be large differences in the *types* of companies started, as they range from one-man consultancies to research-intensive high-tech firms.

We find no indication that prior full-time work experience from industry is associated with a greater likelihood of engaging in patenting activity or the development of research-based companies; this is interesting, as researchers with non-academic work experience are often assumed to be more apt at spotting and exploiting commercial potential.

Joint research projects with private organizations or public institutions are by far the most important formal collaboration activity among the respondents, as 80 pct. of the respondents have engaged in joint research within the past three years. *Consulting, contract research* and *acting as a formal advisor* are less common, but still practiced by a substantial proportion of researchers.

Informal collaboration and *collaboration on teaching* are more common among the respondents than formal collaborations. For example, 83 pct. of respondents have engaged in collaborations on teaching of university students, and 83 pct. have provided informal advice to non-academic organizations.

Among *other forms of dissemination* of academic research, public lectures and talks to non-academic audiences are the most common, followed by publication of articles in the daily press or other popular science outlets, and getting cited in newspaper articles. Moreover, it is interesting to note that almost a third of the respondents have engaged in blogging or other work-related use of social media within the past three years, indicating that digital media are a significant outlet for non-academic dissemination. In addition, results show that engaging in other forms of dissemination is more common among respondents from the soft sciences than it is among their peers from the hard sciences.

[13] The only exception to this was the IT University of Copenhagen, which had a response rate of 42 pct.; however this rate is based on just 29 respondents, as the university only employs 69 full-time researchers, and therefore cannot be meaningfully compared to the response rates from the other six universities that participated in the study.

[14] A number of academic studies examine why senior researchers are more likely to engage with industry; for a review of these studies, see Perkmann et al. (2013).

Box 1: What do we mean by "collaboration with non-academic organizations"?

A key aim of the survey presented in this report was to investigate to which extent academics engage with non-academic organizations. We were interested in both formal and informal mechanisms for collaboration. **"Collaboration"** is therefore defined broadly in this report and includes

- Activities with a view to the **commercialization** of academic research findings e.g. through *patenting* or establishment of *spin-outs*.
- **Formal mechanisms for collaboration** with non-academic organizations in the public or private sector, including *joint research, contract research, consulting* or *(formal) advisory services*.
- Mechanisms for **collaboration on teaching and education**, including involvement of non-academic partners in the *training of university students* or in the *training of researchers* (i.e. PhD and postdoc training), or involvement of academics in the *training of staff in non-academic organizations*.
- **Informal mechanisms for collaboration**, e.g. providing *informal advice* to non-academic organizations, providing *access to research resources* (e.g. data, research instruments, research materials etc.), or *participating in conferences* with a significant number of non-academic organizations.
- **Other forms of dissemination** of research findings, including e.g. public lectures, *publications in the daily press, citations in newspaper articles* and the like, appearances on TV or radio, and work-related *blogging or other social media*.

By **"non-academic organizations"** we refer to *private firms, public sector organizations* (e.g. government agencies and ministries, regional and local authorities, public hospitals and schools, childcare institutions, utility companies), and *third sector organizations* (e.g. interest organizations, unions, non-profit organizations). Please note that for the purposes of this report, the terms "industry" and "private sector" are used interchangeably.

All in all, the survey reveals a very high degree of variation in individual researchers' collaboration behavior: we could find no convincing patterns across universities, scientific disciplines, academic rank or scientific performance[15] in the types of non-academic collaboration mechanisms used by researchers, or in the degrees to which they use these mechanisms.

4. WHAT MOTIVATES RESEARCHERS TO COLLABORATE?

The survey results indicate that academic researchers who engage with the public or private sector do so primarily because they expect that this will benefit their research and, to a lesser extent, teaching activities. The most important motivations for non-academic collaboration were to gain access to funding, ideas and other resources for research (e.g. access to specialized research facilities, expertise, materials etc.), and to test or strengthen the usefulness of their research.

Factors such as improving chances of career advancement, living up to expectations from management and achieving personal financial gain were the least important in motivating researchers to engage with non-academic collaborators.

[15] By "scientific performance", we refer both to scientific productivity (as indicated by the number of publications in scientific journals indexed in Scopus) and scientific impact (as indicated by the average number of citations to those publications).

These findings confirm the general perception that academic researchers eschew monetary gains for the ability to pursue their academic research aims.

Our analysis also reveals substantial differences in the motivations for engaging in non-academic collaboration across universities and scientific disciplines. For example, researchers from the hard sciences are more highly motivated by the possibility of gaining additional funding or access to research facilities or materials than their peers from the soft sciences, presumably because of the significant costs associated with acquiring e.g. the scientific instruments, research materials and laboratory assistance often needed in the hard sciences.

5. WHAT ARE THE CONSEQUENCES OF COLLABORATION?

More than 70 pct. of the respondents indicated that engaging with the non-academic sector has a positive effect on *the quality or scientific impact of their research* and/or on *the quality or relevance of their teaching activities*. This suggests that there are significant complementarities between the traditional core missions of research and teaching on the one hand, and "third mission" activities on the other. More detailed analysis revealed that positive effects on research and teaching are, however, more strongly felt at some universities and in some disciplines than others. Further investigation is needed to identify possible explanations for these differences.

While there is a relatively wide consensus among respondents as to the positive outcomes of non-academic engagement, there is much more variation in the extent to which individual researchers experience negative outcomes. About one in ten researchers "always or often" experiences negative outcomes such as reduced time to spend on research or teaching, publication delays, or restrictions on the availability of data or results to other researchers. Further analysis reveals that these negative consequences are not experienced by the same researchers, but rather that different researchers encounter different negative outcomes of collaboration. This calls for further investigation of the conditions under which collaboration and commercialization activities are associated with negative effects.

6. WHAT ARE THE MAIN BARRIERS TO COLLABORATION?

The survey asked respondents with recent non-academic collaboration experience, and those who do not, to indicate what they see as key barriers to engaging in collaboration and commercialization activities. Respondents were asked to assess 13 possible barriers to engaging in collaboration and commercialization activities, including e.g. conflicting timeframes or goals in academia and industry, difficulties in finding and building good relationships to non-academic partners, concerns regarding the impact of non-academic collaboration on academic freedom, disagreements over intellectual property (IP) etc.

Respondents with recent collaboration experience identified three factors as "key barriers" by approximately one fifth of the respondents with collaboration experience: *lack of prioritization/ reward from university management*, *conflicting timeframes* in non-academic and academic organizations (e.g. short vs. long-term focus), and *conflicting goals* (e.g. making a profit vs. publishing findings).

Respondents with no recent non-academic collaboration experience identified the following main deterrents to collaboration: *difficulties in finding qualified academic partners*, *conflicting goals*, and the perception that their research is

not sufficiently relevant for non-academic organizations. These findings suggest that efforts to stimulate this group of researchers to engage with industry should focus, at least in part, on helping them build networks with potential collaborators.

7. PUTTING COLLABORATION IN CONTEXT

Based on our analysis of the survey report, we suggest some implications and recommendations for future efforts to stimulate university-industry collaboration.

Recognize the importance of informal mechanisms for collaboration and collaboration on teaching and training. Informal mechanisms for collaboration and collaboration on teaching are more common than engaging in formal mechanisms for collaboration, suggesting that more attention should be paid to the importance of such mechanisms (and the time that must be invested in them). This is particularly important as a number of academic studies[16] suggest that less formalized mechanisms of collaboration may play an important role in building and maintaining strong relationships between university researchers and collaboration partners outside academia.

Recognize differences in collaboration behavior across scientific disciplines. Much of the debate surrounding university-industry collaboration is focused on the hard sciences. Our survey results indicate that there are significant differences within the hard sciences that need to be taken into account in efforts to stimulate non-academic collaboration; thus, it is important not to treat the hard sciences as one. Second, the survey results show that many researchers from the social sciences and humanities also engage in collaboration with non-academic actors, suggesting that more attention should be paid to the way these disciplines interact with their surrounding community.

"One size fits all" approaches are unlikely to be effective in motivating collaboration. Survey results indicate that there is substantial variation in the extent, nature, motivations and outcomes of universities' non-academic collaboration. This variation is only partially explained by researchers' university affiliation, scientific discipline, academic rank, and scientific performance, suggesting that individual differences and other factors not covered in this survey also play a role in shaping researchers' collaboration behavior. This implies that individually tailored approaches to stimulating or rewarding non-academic collaboration are likely to be more effective than "one size fits all" approaches. At the very least, generic department or faculty-wide strategies should be complemented by a higher degree of attention to the individual researchers' collaboration motivations, opportunities and experience.

Incentive systems should be based on key motivational factors. The survey confirmed that researchers are far more motivated to engage in non-academic collaboration by expected benefits to their research and/or teaching than by formal requirements, possibilities for career advancement, or opportunities to supplement their personal income. This implies that policies and initiatives to stimulate non-academic collaboration are likely to be more effective if they highlight, and help realize, potential benefits for research and teaching activities. This may be supported by e.g. career-related benefits or explicit requirements to engage in non-academic collaboration, but such tools should not stand alone.

[16] E.g. Klofsten & Jones-Evans (2000); Perkmann et al. (2010); Landry et al. (2010); Abreu & Grinevich (2013).

Build greater insight into the possible negative effects of non-academic collaboration. Far more respondents reported positive effects than negative effects of engaging in non-academic collaboration, and few respondents experienced potential barriers to such collaboration as key barriers. Nonetheless, we suggest that it is important to gain better insight into the circumstances under which (and for whom) these negative effects and barriers emerge, in order to better support productive university-industry collaboration.

Non-academic collaboration should perhaps rather be viewed as a natural complement to research and teaching than as a "third mission". Referring to a "third mission" sends the signal that collaboration with industry is an extra task for researchers, which is more or less distinct from their other professional activities. However, the survey showed that the majority of respondents who engage in such collaboration experience positive benefits to their research and/or teaching. These findings stress the potential synergy effects between research, teaching and non-academic collaboration.

Specialization can lead to more efficient division of labor in academia but may, if taken to the extreme, negatively affect the ability of universities to realize potential synergies between non-academic collaboration on the one hand and research and teaching activities on the other. To which extent should individual researchers specialize in some of the demands made of academics today – e.g. in relation to securing external funding, teaching, engagement with non-academic actors, commercialization of research etc. – instead of trying to do them all simultaneously? Such specialization offers benefits by allowing individuals to focus their resources and thus supports a more efficient division of labor within the research community. If taken too far, however, specialization may also lead to unproductive fragmentation of the community, where researchers who specialize and excel in research are likely to be seen as the "A-team", while those who specialize in teaching or in so-called "third mission" activities are likely to feel increasingly overlooked and underappreciated. Excessive specialization might also limit the extent to which universities succeed in realizing the potential synergies between research, teaching and engagement with the non-academic sector. These synergies appear to be substantial, as a majority of the respondents indicated that engaging with the non-academic sector has a positive impact on research activities and/or teaching.

Finally, survey respondents were asked what, if anything, they would advise university managers and policymakers to do to support productive interaction between university researchers and non-academic organizations. Suggestions included (a) strengthening incentives and/or recognition for engaging in non-academic collaboration, (b) developing indicators for non-academic collaboration, which are tailored to specific disciplines and research areas (taking into account, for instance, differences in collaboration patterns in the hard and soft sciences), (c) strengthening mutual insight and interpersonal networks between industry and academia, (d) greater recognition that good collaborations require an initial investment of resources, (e) seed funding to e.g. support the development of novel (but often uncertain) interactions with non-academic partners, (f) that universities subsidize overhead costs when researchers are trying to establish partnerships to new non-academic partners, and (g) specifically helping young researchers and international researchers to build insight into and networks to industry.

1. ABOUT THE SURVEY

The purpose of DEA's survey of university researchers' engagement with industry and the public sector was to expand the current knowledge of researchers' third mission activities, and to create greater insight into the various types of collaboration and knowledge dissemination with which the researchers engage with the surrounding society.

The survey relies on self-reported data on full-time researchers' perception of the motivations for, barriers to and consequences of their interaction with non-academic institutions within the past three years. Naturally, there are significant limitations in using self-reported data, including for instance the risk that respondents have inaccurate recollection of their collaboration activities or different interpretations of questions asked or terms used in the survey, the subjective nature of their responses etc. Keeping these limitations in mind, self-reported data nonetheless provide a unique perspective on the experiences and perceptions that shape individual researchers' collaborative behavior.

All eight Danish universities were invited to participate in the survey by providing names, academic rank, department affiliation and e-mail addresses for all scientific staff members. All universities except the University of Southern Denmark contributed to the survey. To ensure as relevant a survey population as possible, staff members such as administrative personnel, research assistants, guest researchers, and staff with part-time positions were deleted from the list.

All respondents were guaranteed anonymity in the sense that their identity and responses are known only to the team working on the analysis of survey results, but not made available to universities, the Danish Agency for Science, Technology and Innovation that provided financial support for the survey, or any other party. All lists of employee names, ranks and contact information provided by the participating universities were deleted upon completion of the survey. Finally, in all tables and figures used to report results from the survey, any finding based on less than five observations was left out in order to preserve the anonymity of respondents.

The survey results are presented in the subsequent chapters of this report. For data on variations in the survey results across e.g. universities, scientific disciplines, academic rank, and respondents' scientific performance[17], a background report in the form of an Excel spreadsheet is available for download from DEA's webpage (www.dea.nu/survey-of-university-researchers).

DEA's survey of full-time university researchers' engagement with industry and the public sector was carried out as an online survey that took approximately 15 minutes to complete. Respondents were given the option to complete the survey in Danish or English. In addition, respondents had the option of entering comments into text boxes throughout the survey, allowing them to comment on the survey questions, expand upon their answers, and provide other information which they deemed relevant.

[17.] By "scientific performance", we refer both to scientific productivity (as indicated by the number of publications in scientific journals indexed in Scopus) and scientific impact (as indicated by the average number of citations to those publications). Indicators of scientific impact were normalized for each scientific discipline.

The design of the survey questionnaire was inspired by a review of academic studies of researchers' engagement with the non-academic sector[18] as well as findings and hypotheses generated in a previous study undertaken by DEA.[19] Feedback on the design of the questionnaire was subsequently provided by the Inno-Tech working group under Universities Denmark and by stakeholders from the Danish Agency for Science, Technology and Innovation. Finally, the online questionnaire was subjected to pilot testing by four employees in DEA and nine volunteers from the university sector. Ten researchers agreed to participate in the pilot test,[20] and ultimately nine completed the pilot test.

The survey was launched in early June 2014 and closed at the end of July 2014.[21] During this time, two reminders were sent to researchers who had not yet completed the survey. All recipients of the e-mail invitation and reminders were given the option of clicking a "refuse to participate" link, in which case they were not contacted again.

Using the contact information provided by the universities, invitations to participate in the survey were sent to a total of 13,428 researchers at seven universities. Invitations to 987 researchers never reached their recipient, as the email invitations could not be delivered (presumably due to mistakes in the email addresses, full mailboxes and the like), bringing the actual survey population to 12,441.

3,272 university researchers completed the survey, giving a response rate of 26 pct. An additional 471 responses were incomplete and are therefore not included in the calculation of the response rate. Finally, 452 researchers refused to participate in the survey.

Additional data was collected in connection with the analysis of survey results: publication performance indicators on productivity (as indicated by the number of scientific publications) and impact (as indicated by the number of citations to those publications) were gathered for 71 pct. of the survey respondents.[22] The aim of this additional data collection was to test whether scientific performance affects respondents' propensity to engage in non-academic collaboration or their perceptions of the motivations, outcomes and barriers of such collaboration.[23] So far, our analysis has revealed no clear indications of a relationship between scientific performance and non-academic collaboration; these results are therefore not presented in this report; however, bibliometric data is included in the background report, which is available from DEA's webpage.

[18.] E.g. Klofsten & Jones-Evans (2001); Owen-Smith & Powell (2001); Geuna & Nesta (2006); D'Este & Patel (2007); Bruneel et al. (2010); Davis et al. (2011); D'Este & Perkmann (2011); Larsen (2011); Abreu & Grinevich (2013); Perkmann et al. (2013). [8.] Olmos-Peñuela et al. 2014.

[19.] DEA (2013).

[20.] The pilot test persons included four professors, three associate professors, one former government research institute researcher, and two PhD fellows from the humanities, social sciences, health sciences, natural sciences and technical sciences.[11.] The survey population included all scientific staff members including PhD students and postdocs. As far as possible, research assistants and staff employed solely to undertake teaching activities were excluded.

[21.] During the survey period, another survey focused on quality in higher education and aimed at, among others, university researchers was launched by the Ministry of Higher Education and Science. This is likely to have influenced the response rate negatively, partly due to a feeling among researchers of being "overburdened" with requests to participate in surveys, and partly due to confusion regarding whether the two surveys were connected (as one was conducted on behalf of the Ministry of Higher Education and Science, and DEA's survey was partly funded by an agency under the same ministry).

[22.] Bibliometric data were available in Scopus for 73-81 pct. of respondents with a background in the hard sciences and for just 50 pct. and 62 pct. of respondents from the humanities and the social sciences, respectively. Data collected for each respondent included the absolute number of publications in peer reviewed scientific journals indexed in Scopus, the fractional number of publications (i.e. corrected for the number of co-authors), and the average number of citations per publication. All indicators were also normalized for scientific disciplines, as publication and citation behavior differs significantly across disciplines.

[23.] A large number of academic studies have found evidence of a significant and positive relationship between collaborating with industry or engaging in commercialization of research results on the one hand, and academic researchers' scientific productivity (as indicated by the number of scientific articles published) and, to some extent, their scientific impact (as indicated by the number of citations to their publications), on the other. For a review and discussion of these studies, see Larsen (2011) and Perk-mann et al. (2013).

2. WHO PARTICIPATED IN THE SURVEY?

ABOUT THE SURVEY POPULATION

3,272 university researchers completed the survey on their engagement with industry and the public sector. The respondents account for 26 pct. of full-time researchers from the seven Danish universities that participated in the survey.

Response rates are roughly similar for all universities (21-28 pct., cf. table 1), except for ITU, which has a response rate of 42 pct.

ITU is, however, a particular case in that they only have 69 full-time researchers employed, and just 29 respondents from ITU completed the survey. ITU is therefore left out in tables in this report where responses are compared across universities in order to preserve the anonymity of respondents, who may be easily identifiable when responses are broken down into e.g. discipline or academic rank.

Table 1. *Survey response rate by university*

	AAU	AU	CBS	DTU	ITU	KU	RUC	Total
Response rate	27 pct.	23 pct.	28 pct.	22 pct.	42 pct.	24 pct.	21 pct.	26 pct.
No. of respondents	493	660	180	613	29	1,127	170	3,272

Source: DEA (2014). Survey on university researchers' engagement with industry and the public sector.

Table 2 shows the distribution of the respondent population across universities of employment and disciplines, as indicated by the researchers themselves.

Box 2: University acronyms used in the report

AAU Aalborg University (Aalborg University)
AU Aarhus University (Aarhus University)
CBS Copenhagen Business School
DTU Danmarks Tekniske Universitet (Technical University of Denmark)
ITU IT-Universitetet (IT University of Copenhagen)
KU Københavns Universitet (University of Copenhagen)
RUC Roskilde Universitet (Roskilde University)

Table 2. *Distribution of survey respondents by university and scientific discipline*

	Arts & humanities	Social sciences	Health sciences	Technical sciences	Natural sciences	Agricultural and veterinary sciences	Other	Total
AAU	14 pct.	25 pct.	6 pct.	40 pct.	10 pct.	0 pct.	4 pct.	100 pct. (493)
AU	16 pct.	24 pct.	15 pct.	5 pct.	28 pct.	9 pct.	2 pct.	100 pct. (660)
CBS	6 pct.	88 pct.	-	-	-	-	6 pct.	100 pct. (180)
DTU	0 pct.	5 pct.	3 pct.	62 pct.	27 pct.	2 pct.	2 pct.	100 pct. (613)
ITU	24 pct.	34 pct.	-	31 pct.	-	-	10 pct.	100 pct. (29)
KU	12 pct.	14 pct.	24 pct.	2 pct.	38 pct.	8 pct.	2 pct.	100 pct. (1,127)
RUC	23 pct.	50 pct.	-	-	19 pct.	-	5 pct.	100 pct. (170)
Total no. of obs.	(361)	(729)	(420)	(649)	(857)	(163)	(93)	100 pct. (3,272)

Source: DEA (2014). Survey on university researchers' engagement with industry and the public sector. Values below five observations are left out. Respondents who chose the category "other" usually indicated that they were multidisciplinary and/or did not believe that their field of research (e.g. law or economics) was accurately captured by established scientific disciplines (e.g. the social sciences).

In this report, the term "hard sciences" will be used to refer to the health, technical, natural, agricultural and veterinary sciences, while "soft sciences" refers to social sciences and the arts and humanities.

Table 3 shows the distribution of respondents by their nationality and academic rank. As apparent from the table, two thirds of the survey respondents are Danish. Of the non-Danish respondents, 54 pct. are junior researchers, compared to 29 pct. of the Danish researchers.

Throughout the report, we distinguish between "junior researchers" (i.e. PhD students and postdocs) and "senior researchers" (that is, assistant professors, associate professors, and professors, including clinical professors and professors with special duties).

Table 3. *Distribution of survey respondents by nationality and academic rank*

	PhD fellow	Postdoc	Assistant professor	Associate professor	Professor	Total
Danish	19 pct.	10 pct.	10 pct.	39 pct.	21 pct.	100 pct. (2,112)
Other nationalities	30 pct.	24 pct.	11 pct.	25 pct.	9 pct.	100 pct. (1,013)
Total no. of obs.	(703)	(462)	(333)	(1,086)	(541)	100 pct. (3,125)

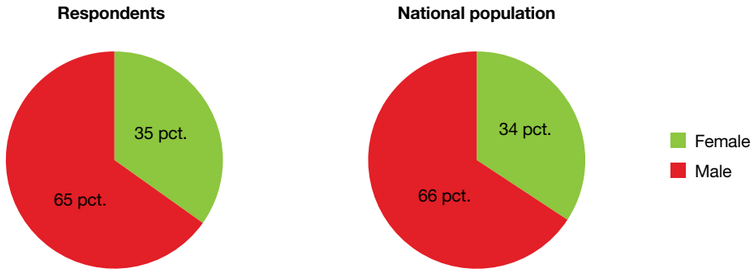
Source: DEA (2014). Survey on university researchers' engagement with industry and the public sector. Please note that the academic rank "researcher" (in Danish, "forsker") is included in the category "assistant professors", while "senior researchers" (in Danish, "seniorforskere" or "seniorrådgivere") is included in "associate professors". Finally, "professors" includes not just full professors but also clinical professors and professors with special duties.

HOW REPRESENTATIVE ARE THE SURVEY RESPONDENTS?

A comparison between the respondent population and the total population of university researchers in Denmark reveals that the survey respondents are highly representative of the national population of researchers as distributed by gender, university and discipline (see figure 1, figure 2 and figure 3, respectively). There is, however, a slight overrepresentation of social scientists and a slight underrepresentation of health scientists among the respondents (cf. figure 3).

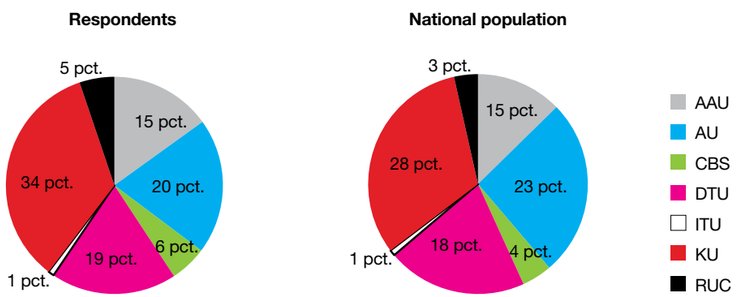
Please note that the number of observations for the total national population varies based on the data available for comparison. This is because figures for the total national population were derived from different sources and therefore based on different approaches to estimating the total population. For instance, in some figures, PhD students are included in the population, which in others they are not.

Figure 1. *Survey respondents and total national researcher population, by gender*



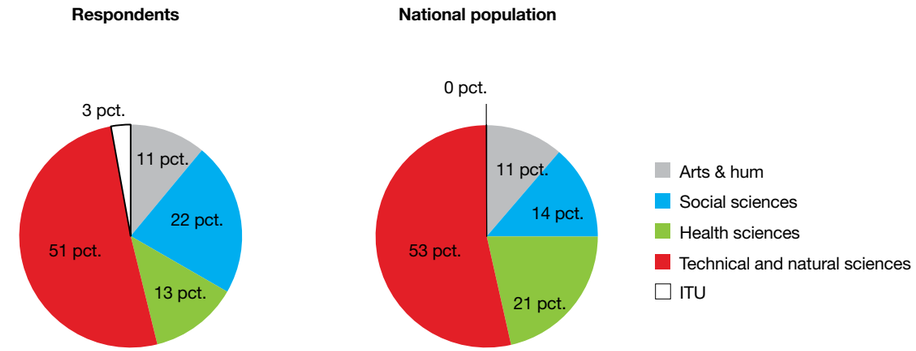
Source: DEA (2014). Survey on university researchers' engagement with industry and the public sector. Ministeriet for Forskning, Innovation og Videregående Uddannelser (2013). Videnskabeligt personale på universiteterne 2012. N(respondents) = 3.111; N(national population) = 9,627.

Figure 2. *Survey respondents and total national researcher population, by university*



Source: DEA (2014). Survey on university researchers' engagement with industry and the public sector. Ministeriet for Forskning, Innovation og Videregående Uddannelser (2013). Videnskabeligt personale på universiteterne 2012. N(respondents) = 3.111; N(national population) = 9,627.

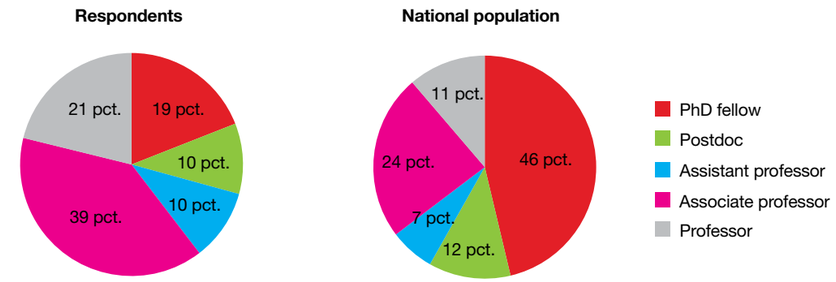
Figure 3. *Survey respondents and total national researcher population, by scientific discipline*



Source: DEA (2014). Survey on university researchers' engagement with industry and the public sector. Universities Denmark (2013). Tal om de danske universiteter 2013. N(respondents)= 3,272; N(national population) = 11,598.

In contrast, the distribution of survey respondents according to academic rank differs significantly from the distribution of the total national population (cf. figure 4). The proportion of junior researchers is underrepresented in the group of survey respondents compared to the national population, where PhD students account for the majority of university researchers. Having an overrepresentation of senior researchers is however seen as a strength rather than a disadvantage for this particular survey, as senior researchers are likely to have more collaboration experience on which to base their responses.

Figure 4. *Survey respondents and total national researcher population, by academic rank*



Source: DEA (2014). Survey of university researchers' engagement with industry and the public sector. Ministeriet for Forskning, Innovation og Videregående Uddannelser (2013). Videnskabeligt personale på universiteterne 2012. Universities Denmark (2012). Universiteternes statistiske beredskab. N(respondents)= 3,272; N(national population) = 17,920.

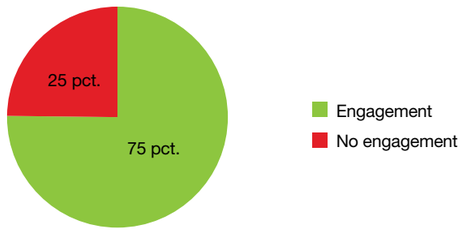
There is limited data on the nationality of the total population of researchers at Danish universities. Data on Danish universities' recruitment show, however, that for the period 2007-2009, 33 pct. of all employed professors, associate and assistant professors were of foreign nationality.[24] However, we still lack information on the nationalities of the total population of researchers.

HOW COMMON IS NON-ACADEMIC COLLABORATION?

According to the respondents, three out of every four respondents have engaged with the non-academic sector in the past three years.

There is however substantial variation across the participating universities (cf. table 4). For example, while 86 pct. of respondents from AAU and 85 pct. of respondents from CBS have interacted with the non-academic sector, merely 66 pct. of respondents from KU engaged in non-academic collaboration.

Figure 5. *Respondents by whether or not they have had some form of engagement with industry and/or the public sector within the past three years*



Source: DEA (2014). Survey on university researchers' engagement with industry and the public sector. N = 3,272.

Table 4. *Percentage of respondents that have engaged in non-academic collaboration within the past three years, by university*

	AAU	AU	CBS	DTU	KU	RUC	Total
Percentage with collaboration	86 pct.	77 pct.	85 pct.	77 pct.	66 pct.	81 pct.	75 pct.
No. of respondents	422	506	153	475	742	137	2,460

Source: DEA (2014). Survey on university researchers' engagement with industry and the public sector. N = 2,460.

[24] Ståhle. En forskerstab i vækst. Forskerpersonale og forskerrekruttering på danske universiteter 2007-2009. UNI•C

More detailed analysis of survey responses reveals that non-academic collaboration is more common among senior researchers than junior researchers. This is not surprising, given that senior researchers are likely to be more visible and attractive partners to industry because of their academic experience and track record. They are also likely to have larger networks outside academia.

Further analysis also shows that non-academic collaboration is most common among respondents from the social sciences (86 pct.), and least common among respondents from the natural sciences (61 pct.). This is rather surprising, since the hard sciences are usually highlighted in the public debate for their extensive collaboration with non-academic organizations. It is possible that this has researchers from the soft sciences who engage in collaboration outside academia therefore had a strong interest in completing the survey and thus raising visibility of their engagement with non-academic actors.

Table 5. *Percentage of respondents that have engaged in non-academic collaboration within the past three years, by university*

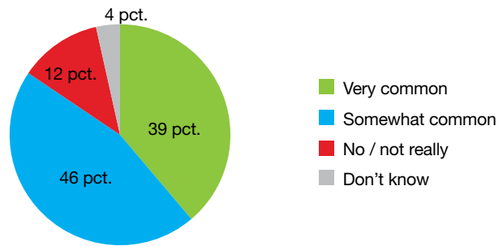
	Arts & humanities	Social sciences	Health sciences	Technical sciences	Natural sciences	Agricultural and veterinary sciences	Total
Percentage with collaboration	79 pct.	86 pct.	66 pct.	82 pct.	61 pct.	83 pct.	75 pct.
No. of respondents	284	628	276	530	527	136	2,460

Source: DEA (2014). Survey on university researchers' engagement with industry and the public sector. N = 2,460.

As stated earlier, 26 pct. of all full-time university researchers at the seven universities included in the study responded to DEA's survey. We know little, however, about how the remaining 74 pct. of university researchers in Denmark interact with the non-academic sector. Therefore we cannot say whether the respondents' level of non-academic collaboration – or, for that matter, their perceptions of the key motivations for, outcomes of, and barriers to such collaboration – are representative of the total population of Danish researchers.

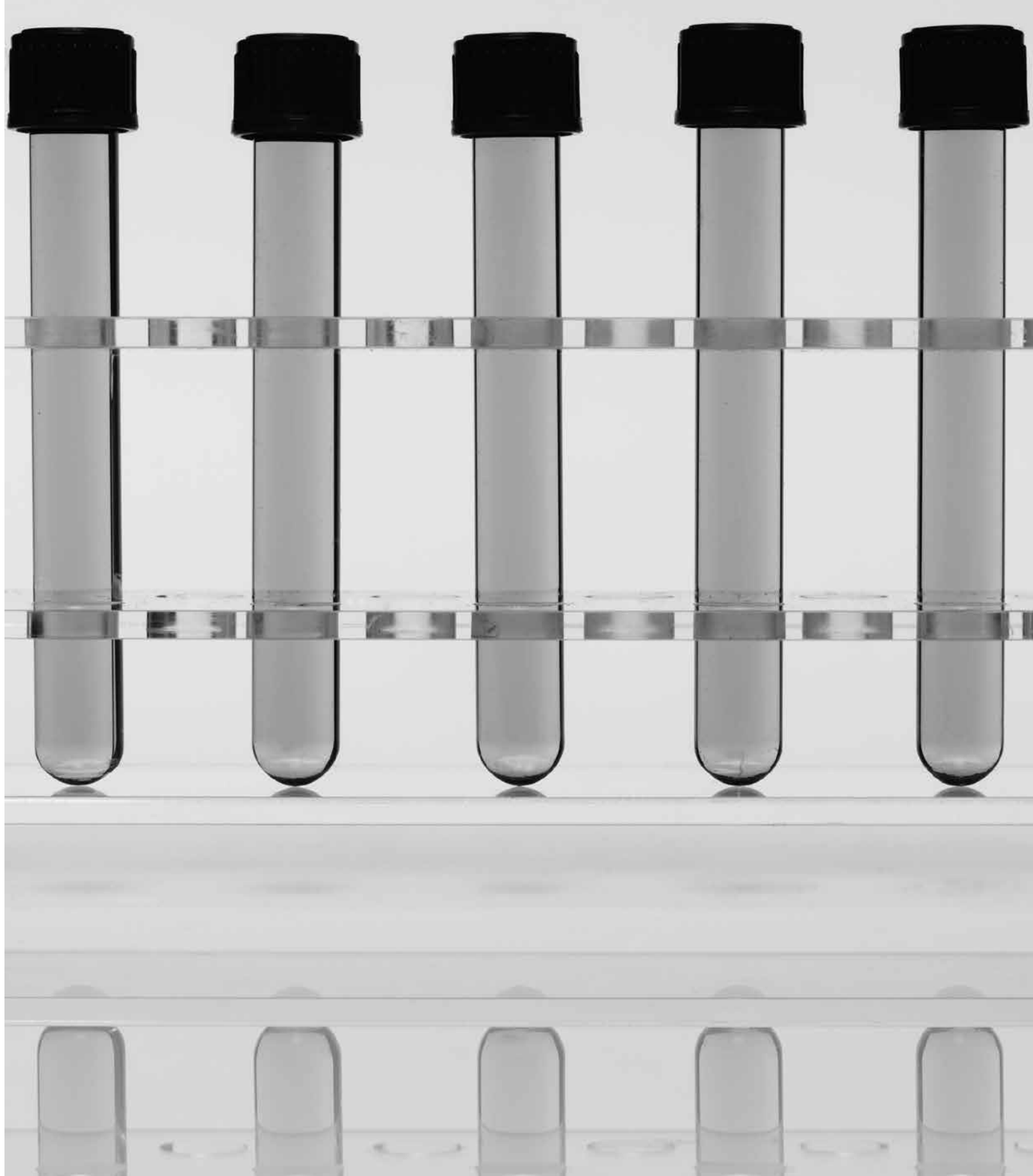
It is, however, worth noting that the vast majority of survey respondents work in research units and departments, where interaction with non-academic organizations is “very” or “somewhat” common (see figure 6).[25] This indicates that researchers who participated in the survey work in research environments where non-academic collaboration is relatively or very common; this may have influenced their propensity to contribute to the survey.

Figure 6. *Respondents’ assessment of the degree to which interaction with non-academic organizations is common among colleagues in their immediate research unit/department*



Source: DEA (2014). Survey on university researchers’ engagement with industry and the public sector. N = 2,460.

[25] Several academic studies have found that academics are influenced in their beliefs and behavior by the people they work closely together with. For example, Louis et al. (1989), Owen-Smith & Powell (2001), Bercovitz & Feldman (2008) and Haeussler & Colyvas (2011) have argued that local norms and behavior in researchers’ departments and academic peer groups can influence researchers’ actions. On a related note, Azoulay et al. (2007) found that having co-authors who have patented in the past increases the likelihood of engaging in patenting; they also found that researchers were more likely to patent if employed at universities with large patent portfolios. More recently, Tartari et al. (2014) found that peer effects are stronger for early career individuals and weaker for so-called “star” (or top) scientists; the authors also argue that academic researchers are influenced by the behavior of their peers in their engagement with industry, because they compare themselves to their peers, using them as a benchmark for their own goals and behavior. See also Perkmann et al. (2013) for a review of several of these and other related studies that indicate that paying attention to norms and behavior in researchers’ immediate research environment or other peer reference group can play an important role in efforts to stimulate university-industry interaction.

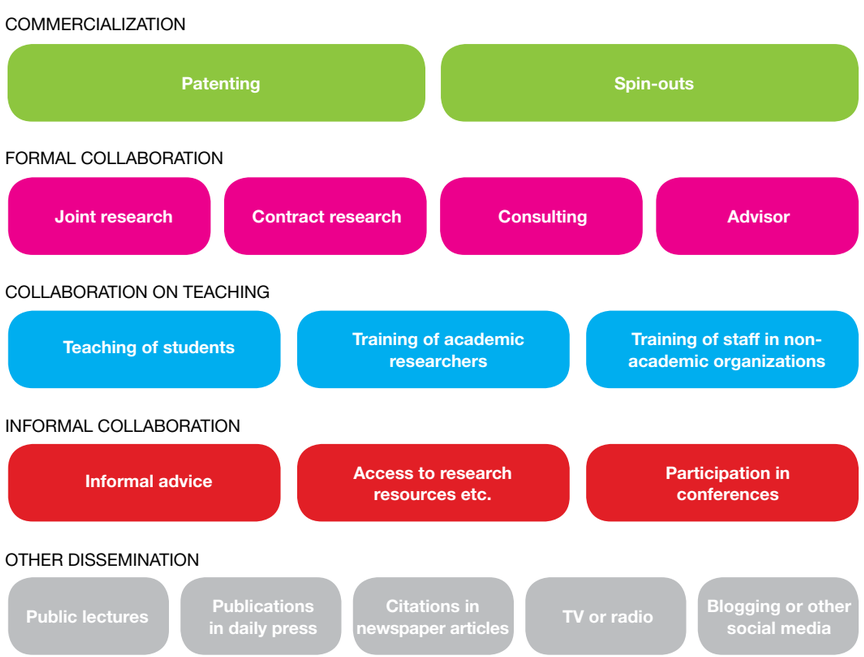


3. HOW MUCH AND WHAT TYPES OF COLLABORATION DO RESEARCHERS ENGAGE IN?

University researchers engage in a variety of different collaboration activities with non-academic organizations, from formal to informal collaboration, and from commercialization activities to broader dissemination activities. This chapter zooms in on researchers' interaction with the surrounding society; thus, the chapter focuses solely on the 75 pct. of respondents who have engaged in some degree of non-academic collaboration within the past three years.

"Collaboration" is defined broadly in this report and includes the activities illustrated in figure 7 and explained in table 6. The activities are not ranked in any order of importance, but (roughly) listed in decreasing levels of formalization and resources required on behalf of the collaborating parties.

Figure 7. *Respondents by whether or not they have had some form of engagement with industry and/ or the public sector within the past three years*



Source: DEA (2014). Survey on university researchers' engagement with industry and the public sector.

By **"non-academic organizations"** we refer to *private firms, public sector organizations* (e.g. government agencies and ministries, regional and local authorities, public hospitals and schools, childcare institutions, utility companies), and *third sector organizations* (e.g. interest organizations, unions, non-profit organizations). Please note that for the purposes of this report, the terms "industry" and "private sector" are used interchangeably.

Table 6. *Types of non-academic collaboration included in the survey*

Type of mechanisms	Industri, råstofindvinding og forsyningsvirksomhed
Activities with a view to the **commercialization** of academic research findings	*Patenting activities* i.e. disclosure of inventions to the university technology transfer office (TTO) or being listed as inventor on a patent application. Spin-outs i.e. starting a company based on personal research.
Formal mechanisms for research collaboration with non-academic organizations	*Joint research:* collaboration on research projects with non-academic organizations. *Contract research:* original (often applied[26]) research commissioned by and undertaken for non-academic organizations. *Consulting activities:* non-original expert knowledge provided to non-academic organizations. *Formal advisory services:* acting as a formally appointed advisor to non-academic organizations (e.g. as member of advisory board or expert panel). Income from consulting and advisory services may accrue to the university or directly to the academic researcher.[27]
Mechanisms for **collaboration on teaching and education**	*Teaching of students:* involvement of non-academic partners in the training of university students e.g. in connection with guest lectures, student projects and theses etc. *Training of academic researchers* refers to collaboration on joint training of PhD students and/or postdocs. *Training of staff in non-academic organization* refers to the involvement of academic researchers in the training of staff in non-academic organizations.
Informal mechanisms for collaboration (these mechanisms are informal in the sense that they are not usually formalized via contracts)	Providing *informal advice* to non-academic organizations e.g. through personal contacts or participation in meetings etc. Providing non-academic partners with access to *research resources* (e.g. data, research instruments, research materials etc.) *Participation in conferences* with a significant number of non-academics.
Other forms of dissemination of research findings	*Public lectures, publications in the daily press, citations in newspaper articles* and the like, appearances on *TV or radio*, and work-related *blogging or other social media*.

26. Van Looy et al. (2004).
27. D'Este & Perkmann (2011).

Box 3: What can we learn from academic research?

D'Este & Patel (2007) pointed out that university-industry collaboration is not a new phenomenon. They also argued that empirical studies indicate that such collaboration is, however, increasing in volume, and that there is increasing variety in the types of interaction that we see between universities and companies. However, the intensity of university-industry interactions differs significantly across sectors and industries, and is higher in science-based industries (see e.g. Pavitt 1984; Meyer-Krahmer & Schmoch 1998).

Policymakers tend to place significant emphasis on the commercialization of academic research through the establishment of spin-out firms based on university research and the licensing or sale of university-owned patents, often overlooking the existence and importance of other channels for interaction between universities and the non-academic world.

Academic research suggests that these "other channels"[28] are both greater in overall volume and more valuable than commercialization activities. For example, Cohen et al. (2002) found that firms place greater value on collaboration with academia (e.g. in the form of consulting, contract research and joint research) than on the licensing of academic patents. Agrawal & Henderson (2002) found that transfer of patents accounted for less than 10 pct. of knowledge exchange from MIT to industry. In addition, universities generally make more money from various forms of collaborative projects than from the sale of patents (Perkmann et al. 2011).

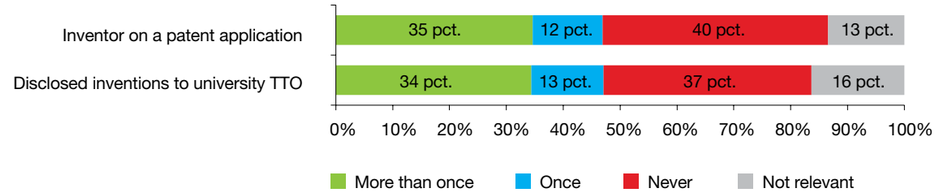
In addition, research indicates that commercialization activities and other forms of interaction between universities and industry are not entirely distinct from each other. Rather, commercialization is often the result or a subsequent activity of direct collaboration between a university and one or more non-academic organizations (Perkmann et al. 2013). On a related note, Landry et al. (2010) used data from a survey of Canadian researchers to look for complementarities between various mechanisms for interacting with industry. They hypothesized that engaging in one form of interaction might increase the returns of engaging in more of another form of interaction, and expected to find evidence of interdependence between certain mechanisms for interaction. Among other things, the authors found evidence of several "portfolios" of mechanisms for interacting with industry at the level of the individual researcher, one of which is a portfolio consisting of interdependent and complementary activities that include publications, patenting, spin-off creation, consulting and informal knowledge transfer. They also investigated the importance of a range of factors on the relationship between different mechanisms for university-industry interaction. The main implication of their study is that mechanisms for collaboration and commercialization should not be studied in isolation of each other, but rather approached jointly.

[28] A growing number of academic studies have opened investigations into these other channels (e.g. Klofsten & Jones-Evans 2000; D'Este & Patel 2007; Perkmann et al. 2010; Landry et al. 2010; D'Este & Perkmann 2011; Abreu & Grinevich 2013).

PATENTING (HARD SCIENCES ONLY)

Almost half the respondents from the hard sciences have engaged in patenting activities in the past three years. More precisely, 47 pct. have disclosed inventions to the university technology transfer office, and 47 pct. have been listed as an inventor on one or more patent applications (see figure 8).

Figure 8. *Respondents' patenting activities in the past three years*



Source: DEA (2014). Survey on university researchers' engagement with industry and the public sector. N(Been listed as an inventor on a patent application) = 1,539; N(Disclosed inventions to the university TTO (or similar organization)) = 1,530.

Box 4: Detailed findings

This box presents findings from more in-depth analysis of survey responses. Researchers' assessments of their patenting activities in the past three years were tabulated with respondents' university of employment, scientific discipline, academic rank, scientific performance and prior, non-academic work experience. Relevant findings are presented below. For more details, please refer to the background report.

The percentage of respondents that have *disclosed inventions to university technology transfer offices* "more than once" is:

- Highest in agricultural sciences (41 pct.) and lowest in technical sciences (30 pct.).
- Higher among senior researchers (38 pct. compared to 27 pct. of junior researchers), which is not surprising, as junior researchers are likely to spend more time meeting the immediate goals in their PhD or postdoc position and establishing a research career than engaging in patenting.

Similarly, the percentage of respondents that have been listed as an *inventor on a patent application* "more than once" is:

- Highest in the agricultural sciences (44 pct.) and lowest in the technical sciences (29 pct.).
- Higher among senior researchers (38 pct. compared to 27 pct. of junior researchers), which, is stated above, is not surprising.

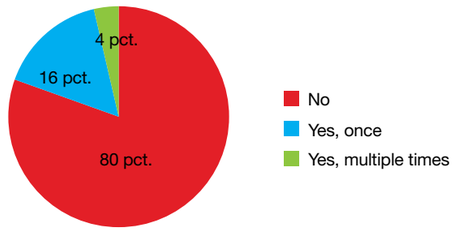
Interestingly, there is no significant difference in patenting activity between respondents who have full-time work experience from outside academia, and respondents who have only held full-time employment in academia.

SPIN-OUT COMPANIES

One in every five university respondents has helped start a company based on their research at some point in their academic career (see figure 9). Four percent have done so more than once.

Analysis of respondents' optional comments to this question reveals, however, that there are large differences in the types of companies started. For example, companies founded range from one-man consultancies to research and capital intensive, high-tech firms. Moreover, while some respondents have been driving forces in the establishment of a company, others have taken on a more passive role, leaving the development of the business to partners.

Figure 9. *Respondents' spin-out activities (based on their entire academic career)*



Source: DEA (2014). Survey on university researchers' engagement with industry and the public sector. N = 2,457.

Box 5: Detailed findings

This box presents findings from more in-depth analysis of survey responses. Researchers' assessments of their patenting activities in the past three years were tabulated with respondents' university of employment, scientific discipline, academic rank, scientific performance and prior, non-academic work experience. Relevant findings are presented below. For more details, please refer to the background report.

The percentage of respondents that have once in their career started a company based on their own research is, in line with findings regarding recent patenting activity, highest among senior researchers (19 pct. compared to 8 pct. of junior researchers).

There are, however, no significant differences in the percentage of respondents that have started a company based on their own research when grouped by university affiliation, scientific discipline or whether or not they have prior work experience from the industry.

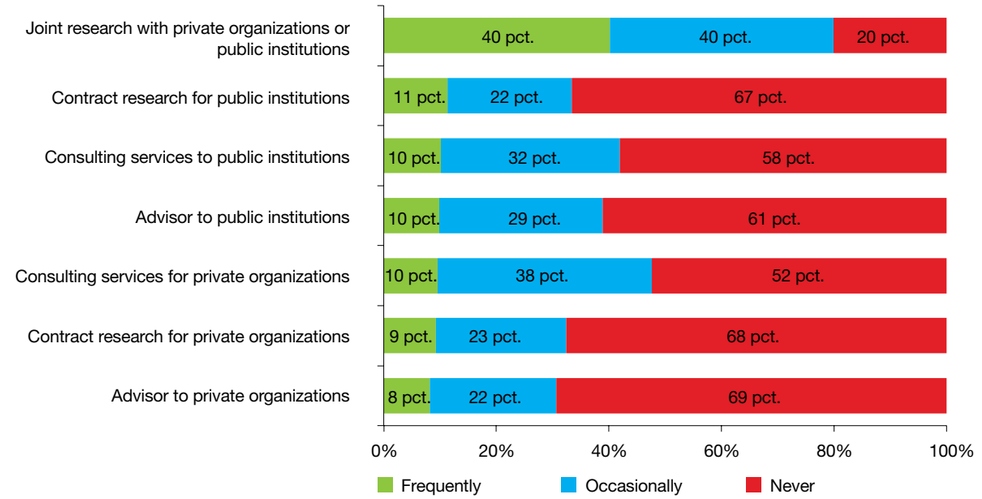
FORMAL COLLABORATION

Joint research projects with private organizations or public institutions are by far the most frequent formal collaboration activity among the respondents, as 80 pct. of the respondents have participated in joint research within the past three years (see figure 10). Half of these respondents frequently engage in joint research, while the other half do so occasionally.

42 pct. and 48 pct. of respondents have provided *consulting services* to private organizations or public institutions, respectively, during the same period.

Finally, 30-39 pct. of respondents have undertaken *contract research* or *acted as advisors* to public or private organizations during the last three years.

Figure 10. *Respondents' participation in formal, non-academic collaboration mechansims in the past three years*



Source: DEA (2014). Survey on university researchers' engagement with industry and the public sector. N(Joint research) = 2,386; N(Contract research for public institutions) = 2,260; N(Consulting to public institutions) = 2,291; N(Advisor to public institutions) = 2,289; N(Consulting to private organizations) = 2,293; N(Contract research for private organizations) = 2,267; N(Advisor to private organizations) = 2,267.

Box 6: Detailed findings

This box presents findings from more in-depth analysis of survey responses. Researchers' assessments of their formal collaboration activities in the past three years were tabulated with respondents' university of employment, scientific discipline, academic rank and scientific performance. Relevant findings are presented below. For more details, please refer to the background report.

The percentage of respondents that frequently participate in *joint research projects with private organizations or public institutions* is:

- Highest at DTU (52 pct.) and lowest at CBS, KU, and AU (30, 33 and 37 pct., respectively)
- Highest for the hard sciences (49 pct.) and lowest for the soft sciences (26 pct.)

The percentage of respondents that frequently provide *consulting services*

- To private institutions is highest for professors (13 pct.) and lowest for PhD students and postdocs (5 and 6 pct., respectively). These findings are not surprising, as professors are likely to have more expertise upon which to base their non-academic collaboration. Moreover, they are likely to be more visible to potential non-academic partners and to have wider and stronger networks outside academia, all of which increase the likelihood of being called upon as a collaboration partner, consultant or advisor.
- To public institutions, similarly, is highest for professors (15 pct.) and lowest for PhD students and postdocs (6 and 4 pct., respectively).

The percentage of respondents that frequently act as *advisors*

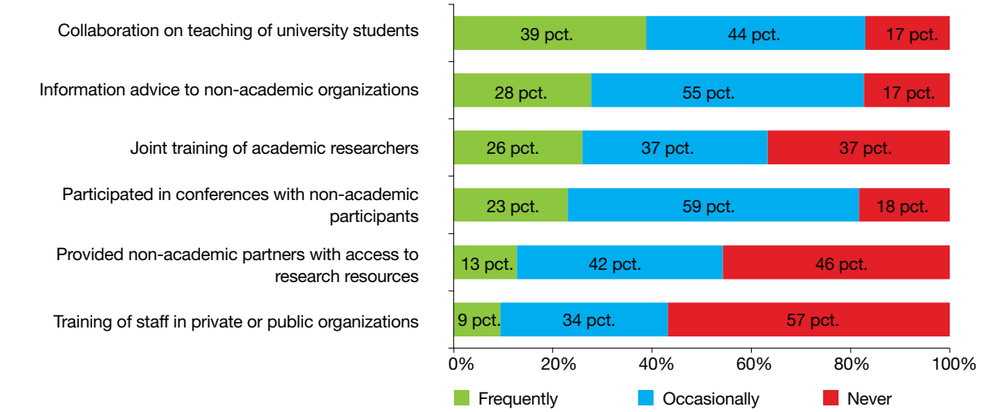
- To private institutions is highest at CBS and AAU (14 and 12 pct. respectively), and lowest at DTU (3 pct.). It is somewhat surprising that DTU, with its strong ties to industry, scores relatively low on this type of interaction. It is also highest for professors (19 pct.) and lowest for PhD students and postdocs (2 and 3 pct., respectively), which, as for participation in consulting services, is not surprising.
- To public institutions is, as expected, highest for professors (21 pct.) and lowest for PhD students and post-docs (2 pct.).

INFORMAL COLLABORATION AND COLLABORATION ON TEACHING

Informal collaboration activities are more common among the respondents than formal collaborations.

The most common of the activities listed in figure 11 are *collaboration on teaching of university students* (rated as a "frequent" or "occasional" activity by 83 pct. of respondents), and providing *informal advice to non-academic organizations* (83 pct.).

Figure 11. *Respondents' participation in informal collaboration and collaboration on teaching in the past three years*



Source: DEA (2014). Survey on university researchers' engagement with industry and the public sector. N(Collaboration on teaching) = 2,407; N(Informal advice) = 2,424; N(Joint training of researchers) = 2,374; N(Conferences) = 2,415; N(Access to research etc.) = 2,384; N(training of non-academic staff) = 2,372.

Box 7: Detailed findings

This box presents findings from more in-depth analysis of survey responses. Researchers' assessments of their informal collaboration activities in the past three years were tabulated with respondents' university of employment, scientific discipline, academic rank and scientific performance. Relevant findings are presented below. For more details, please refer to the background report.

The percentage of respondents that frequently provide *informal advice to non-academic organizations* is:

- Highest for the agricultural and technical sciences (38 and 34 pct., respectively), and lowest in health and natural sciences (20 and 21 pct. respectively).
- Higher for senior researchers (32 pct. compared to 18 pct. of junior researchers). As mentioned earlier, it is to be expected that senior researchers have more expertise and advice to give, taking into account their relative seniority and length of their careers.

The percentage of respondents that frequently *participate in conferences with non-academic participants* is:

- Highest for the technical and agricultural sciences (31 and 30 pct., respectively), and lowest for the health sciences, natural sciences and humanities (14 and 18 pct., respectively).
- Highest for senior researchers (27 pct.) as opposed to junior researchers (13 pct.).

The percentage of respondents that frequently *participate in joint training of academic researchers* is:

- Higher for the hard sciences (31 pct.) than for the soft sciences (17 pct.).

The percentage of respondents that frequently *collaborate on teaching of university students* is:

- Highest at AAU and CBS (47 pct.), and lowest at RUC and AU (29 and 30 pct., respectively).
- Highest for technical sciences (46 pct.) and lowest for health sciences and natural sciences (32 and 34 pct., respectively).
- Higher for senior researchers (44 pct. compared to 27 pct.).

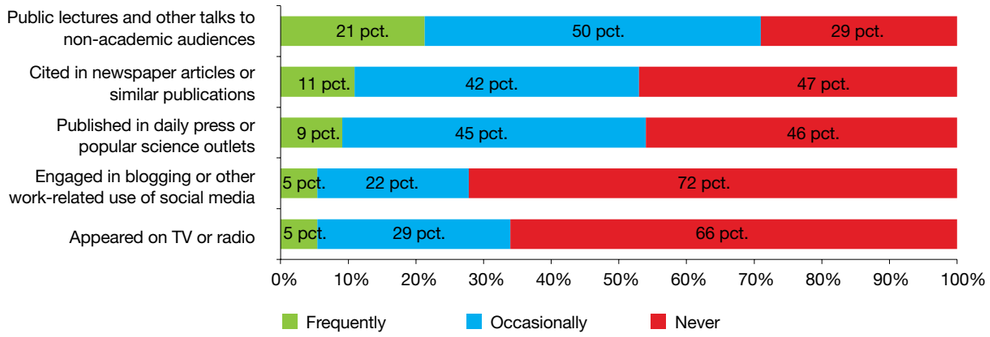
OTHER FORMS OF DISSEMINATION

Almost three fourths of the respondents have *given public lectures and other talks to non-academic audiences* in the past three years. More than one fifth have done so frequently.

Other common forms of dissemination to non-academic audiences are publishing articles in the daily press or other popular science outlets (54 pct. of respondents) and receiving citations in newspaper articles or similar publications (53 pct.).

It is interesting to note that almost 30 pct. of the respondents have engaged in blogging or other work-related use of social media in the past years, indicating that digital media are a significant outlet for non-academic dissemination.

Figure 12. *Respondents' participation in informal collaboration and collaboration on teaching in the past three years*



Source: DEA (2014). Survey on university researchers' engagement with industry and the public sector. N(public lectures and other talks to non-academic audiences) = 3,158; N(cited in newspaper articles or similar publications) = 3,141; N(published articles in the daily press or popular science outlets) = 3,155; N(engaged in blogging or other work-related use of social media) = 3,140; N(appeared on TV or radio).

Box 8: Detailed findings

This box presents findings from more in-depth analysis of survey responses. Researchers' assessments of their patenting activities in the past three years were tabulated with respondents' university of employment, scientific discipline, academic rank and scientific performance. Relevant findings are presented below. For more details, please refer to the background report.

The percentage of respondents that have "frequently" given *public lectures and talks to non-academic audiences* is:

- Highest at AU, CBS and AAU (27, 26, and 25 pct., respectively), and lowest at DTU (13 pct.) and KU (19 pct.).
- Higher for the soft sciences (31 pct. compared to 16 pct. for the hard sciences).
- Higher for senior researchers (29 pct. compared to 8 pct. for junior researchers).

The percentage of respondents that have *published articles in the daily press or other popular science outlets* is:

- Higher for the soft sciences (14 pct. compared to 7 pct. for the hard sciences).
- Higher for senior researchers (13 pct. compared to 4 pct. for junior researchers).

The percentage of respondents that have been *cited in newspaper articles or similar publications* is:

- Higher at CBS and RUC (17 pct.) and lowest at DTU (4 pct.).
- Higher for the soft sciences (19 pct. compared to 7 pct. for the hard sciences).
- Higher for senior researchers (16 pct. compared to 3 pct. for junior researchers).

The percentage of respondents that have *engaged in blogging or other work-related use of social media* is:

- Higher for the soft sciences (9 pct. compared to 3 pct. for the hard sciences).

The percentage of respondents that have *appeared on TV or radio* is:

- Higher for the soft sciences (10 pct. compared to 3 pct. for the hard sciences).
- Higher for senior researchers (8 pct. compared to 1 pct. for junior researchers).

COLLABORATION PATTERNS

All in all, the survey reveals a very high degree of variation in individual researchers' collaboration behavior: we could find no convincing patterns across universities, scientific disciplines, academic rank or scientific performance in the types of non-academic collaboration mechanisms used by researchers or in the degrees to which they use these mechanisms.

Nonetheless, three overall groups of researchers are discernable from the data, when we group respondents who have engaged in some form of non-academic collaboration within the past three years by the *types* of interaction they have engaged in and by the *degree* to which they employ these mechanisms. To simplify the analysis, mechanisms for collaboration were grouped into six categories: *joint research, contract research, consulting and advisor activities, informal collaboration, collaboration on teaching and/or training*, establishment of *spin-outs*, and *other dissemination* (cf. table 7). A total of 2,230 respondents had answered all questions regarding these types of collaboration.[29]

The largest group consists of 450 individuals who "never" or only "occasionally" engage in the various mechanisms for non-academic collaboration. Thus, this group consists of researchers who have had some level of non-academic interaction within the past three years, but who do not engage extensively in any one form of collaboration.

Another group consisting of 174 respondents stands out by frequent engagement in collaboration on teaching and/or training. This group is interesting, since most discussions on researchers' interaction with non-academic organizations tend to focus on commercialization activities and formal collaboration. Nevertheless, here is a group that tends to focus solely collaboration on teaching and training, although these activities are not necessarily rewarding for a research career at Danish universities that tend to favor scientific publication (see The Danish Accreditation Institution 2014; DEA 2014b).

Finally, a group of 107 individuals are characterized by frequent engagement in joint research projects with private organizations or public institutions.

There are no significant differences in respondents' distribution across university, scientific discipline, academic rank or scientific performance between the three groups.

Table 7. *Three largest groups of respondents with similar collaboration patterns*

Number of respondents in group	Joint research	Contract research, consulting, advisor	Informal collaboration	Collaboration on teaching and/or training	Spin-outs	Other dissemination
450	Never/occasionally	Never/occasionally	Never/occasionally	Never/occasionally	No	Never/occasionally
174	Never/occasionally	Never/occasionally	Never/occasionally	Frequently	No	Never/occasionally
107	Frequently	Never/occasionally	Never/occasionally	Never/occasionally	No	Never/occasionally

Source: DEA (2014). Survey on university researchers' engagement with industry and the public sector. N= 2,230.

[29] Patenting activity was left out of this part of the analysis, because data was only available for respondents from the hard sciences.

4. WHAT MOTIVATES RESEARCHERS TO COLLABORATE?

This chapter focuses on the factors that motivate researchers to engage with the private or public sector and/or to pursue the non-academic utilization of their research.

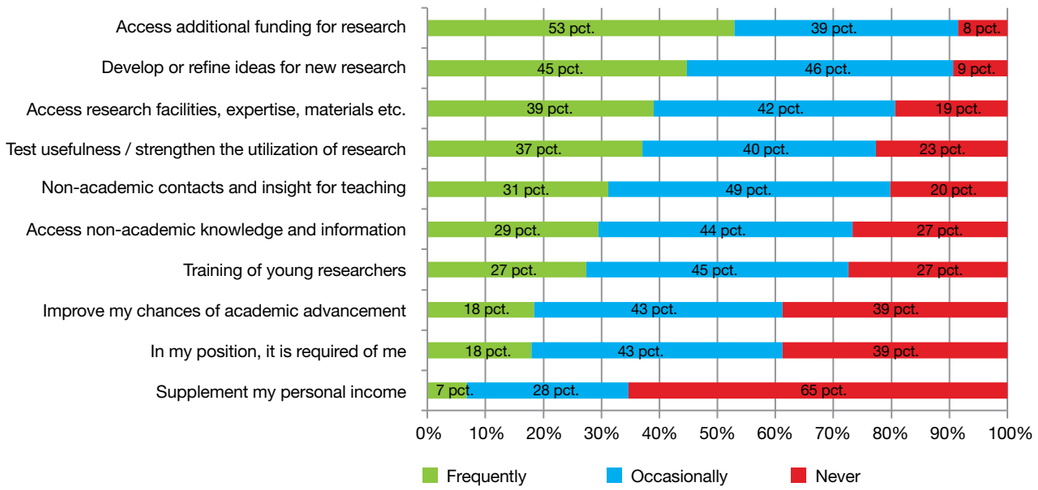
Researchers who have engaged in some form of collaboration with public or private sector organizations within the past three years were asked how important the factors listed in figure 13 are in motivating their decision to engage with non-academic partners and/or to pursue the non-academic utilization of their research by applying for patents on research results or by starting spin-out companies.

The top three motivational factors identified by respondents were:

- *Access additional funding for research* from public and/or private funding sources (rated as "very important" or "important" to 92 pct. of respondents)
- *Develop or refine ideas for new research* (91 pct.)
- *Access research facilities, expertise, materials* etc. for use in research (81 pct.).

Other important motivations were: to gain access to *non-academic contacts and insight for teaching* (80 pct.), to *test the usefulness / strengthen the utilization of their research* (77 pct.), to *access non-academic knowledge and information* e.g. about proprietary R&D, key trends, user needs etc. (73 pct.), and to enable or support the *training of young researchers* (73 pct.).

Figure 13. *Factors motivating researchers to engage with the non-academic sector*



Source: DEA (2014). Survey on university researchers' engagement with industry and the public sector. N(funding) = 2,427; N(ideas) = 2,426; N(facilities etc.) = 2,413; N(test) = 2,421; N(teaching) = 2,415; N(knowledge etc.) = 2,415; N(training) = 2,400; N(advancement) = 2,410; N(required) = 2,407; N(income) = 2,409.

Less than 20 pct. of respondents were strongly motivated to engage with the non-academic sector in order to *improve chances of academic advancement* or because *it is expected of them in their positions*. Finally, only 7 pct. of the respondents indicated *supplementing personal income* as a "very important" motivational factor. Indeed, two thirds of the respondents are, by their own account, "not at all" motivated by the prospect of higher personal income, lending support to the general perception that academics are not particularly motivated by personal financial gain.

This is illustrated by the following quote from one of the respondents:

… Contact with industry … puts my research to the test, because it is only through interaction with firms that my research can be seen in a wider context and tested by a larger group of people. This provides me with a type of necessary feedback, which leads to new ideas and even better research. … Being in contact with industry has nothing to do with my career: It's just a lot more fun and motivating when you see your research being put to use in the real world. [translated from Danish]

Overall, the results reported in this chapter are highly consistent with findings from academic research, cf. box 9.

Box 9: What can we learn from academic research?

It is widely recognized that university researchers are motivated by a different set of values and goals than their peers in industry (see e.g. Dasgupta and David 1994; Merton 1973; Siegel et al. 2003). Generally, academics collaborate with industry in order to acquire additional funding for research, to test the practical applications of their research, to gain new insight into their area of research, to keep abreast of industry problems (e.g. for use in developing new research projects), and to gain access to industry skills and facilities (see e.g. Lee 2000).

More recent work has investigated academics' motivations to engage in patenting. Several studies have found that academic researchers patent, not because they expect financial rewards, but rather to boost their scientific reputation and visibility (Göktepe & Mahagaonkar 2009). Other studies confirm that academics engage in entrepreneurial activities first and foremost in order to enhance their academic position, to further their research, to demonstrate the value of their research, and/or to attract additional funding for research (see Fini et al. 2009; O'Gorman et al. 2008).

D'Este & Perkmann (2011) investigated the drivers of university-industry collaboration and commercialization activities. They found that motivations have a significant influence on the frequency of interactions that academic researchers engage in, and that academics are motivated to engage in different mechanisms for different reasons. For example, commercialization (as in the commercial exploitation of technology or knowledge) was important in motivating researchers to engage in patenting activity and found spin-outs, while research-related reasons such as learning from industry and attracting additional funding for research were the most important driver for collaboration (e.g. joint research, consulting, contract R&D etc.), indicating that academic researchers engage in collaborative projects, because it benefits their academic research.

Box 10: Detailed findings

This box presents findings from more in-depth analysis of survey responses. Researchers' assessment of factors that motivate them to engage in non-academic collaboration or commercialization activities were tabulated with respondents' university of employment, scientific discipline, academic rank and scientific performance. Relevant findings are presented below. For more details, please refer to the background report.

The percentage of respondents that rated *accessing additional funding for research* as a "very important" motivation to engage in non-academic collaboration is:

- Highest at DTU (63 pct.) and lowest at CBS,RUC and KU (43, 44 pct., and 47 pct., respectively).
- Higher for the hard sciences (61 pct.) than for the soft sciences (40 pct.). This is unsurprising in view of the significant costs associated with acquiring e.g. the scientific instruments, research materials and laboratory assistance often needed in the hard sciences.

The percentage of respondents that rated *developing or refining ideas for new research paths and projects* as a "very important" motivation to engage in non-academic collaboration is:

- Highest at AAU (58 pct.), DTU (50 pct.), CBS (47 pct.) and RUC (45 pct.), with fewer AU and KU respondents rating this motivation factor as "very important" (39 and 38 pct., respectively).
- Highest for the technical and agricultural sciences (53 and 50 pct., respectively), which is unsurprising as both these disciplines are known to have good ties to relevant private sectors. It is lowest for the health sciences (35 pct)., while 41, 42 and 45 pct. of respondents from the natural sciences, social sciences and humanities, respectively, rated it as "very important."

The percentage of respondents that rated *accessing research equipment, facilities, expertise or materials* as a "very important" motivation to engage in non-academic collaboration is:

- Highest in the health and technical sciences (45 and 49 pct., respectively), and lowest in the soft sciences (32 pct.). Again, this is unsurprising in view of the greater reliance on specialized research equipment and resources, which is generally seen in the hard sciences.
- Highest at DTU (48 pct.) and lowest at AU and KU (32 and 36 pct. respectively). This may reflect the fact that DTU is a monofaculty university engaged almost exclusively in hard sciences, while both AU and KU are multifaculty universities with large humanities and social science faculties, which is likely to bring down the average 'score' of the respondents on this particular question.
- Highest for young researchers (53 pct. compared to 33 pct.). A possible explanation is that some PhD students and postdocs explore research questions or techniques that are novel compared to established research in their research group, and therefore have specialized research needs.

The percentage of respondents that rated *testing the usefulness and/or strengthening the utilization/commercialization of their research* as a "very important" motivation to engage in non-academic collaboration is:

- Highest at AAU (45 pct.) and DTU (54 pct.) – both known for their university-wide emphasis on engaging with non-academic organizations – and lowest at KU, AU and RUC (all at 29-30 pct.).
- Highest for the technical (57 pct.) and agricultural sciences (49 pct.), and lowest in the humanities, social sciences and health sciences (24, 28 and 27 pct., respectively). Again, this is not a surprising finding, as both the technical and agricultural sciences traditionally have strong ties to the business sectors to which they deliver graduates and research knowledge.
- Highest for young researchers (44 pct., compared to 34 pct. for senior research staff).

The percentage of respondents that rated *"in my position, non-academic collaboration is expected of me"* as a "very important" motivation to engage in non-academic collaboration is:

- Highest at AAU (22 pct.) and DTU (23 pct.), and lowest at CBS and KU (11 and 13 pct., respectively).
- Highest in the agricultural and technical sciences (34 and 24 pct., respectively, compared to 13-16 pct. for the remaining disciplines). As mentioned, both the agricultural and technical sciences have traditionally had strong ties to related business sectors, why this finding is not surprising.

The percentage of respondents that rated *accessing non-academic contacts and/or insights for use in teaching* as a "very important" motivation to engage in non-academic collaboration is:

- Highest at CBS (43 pct.), AAU (41 pct.) and RUC (38 pct), and lowest at AU (23 pct.).
- Highest among respondents from the social sciences and humanities (39 pct. compared to 26 pct. for respondents from the hard sciences).
- Lowest among postdocs (25 pct.), and highest among assistant professors (39 pct.).

The percentage of respondents that rated *training of young researchers* as a "very important" motivation to engage in non-academic collaboration is:

- Higher among senior researchers, not surprisingly, as they are responsible for providing (and often also attracting funding for) this training.
- Highest in the hard sciences (31 pct. compared to 20 pct. for respondents from the soft sciences).

The percentage of respondents that rated *"non-academic collaboration advances my career"* as a "very important" motivation to engage in non-academic collaboration is:

- In line with previous findings, highest and AAU and DTU (26 pct. in both universities). It was also highest in the technical sciences (28 pct.) and lowest in the soft sciences (13 pct.).
- Highest for young researchers (31 pct. compared to 13 pct. of senior respondents). This is to be expected, given that they will be looking for their next job within a relatively short period of time, either inside or outside academia; in both cases, collaboration experience is often a plus.

The percentage of respondents that rated *accessing non-academic knowledge or information* (e.g. about proprietary R&D, key trends, user needs etc.) as a "very important" motivation to engage in non-academic collaboration was:

- Highest at AAU (40 pct.), CBS (39 pct.) and DTU (35 pct.).
- Highest in the social sciences (39 pct.), and lowest in the health and natural sciences (21 and 16 pct., respectively).

The percentage of respondents that rated *supplementing their personal income* as a "very important" motivation to engage in non-academic collaboration is:

- Higher at CBS (15 pct., compared to 4-7 pct. in the other universities).
- Slightly higher for the soft sciences (9 pct.) than other sciences (5 pct.).

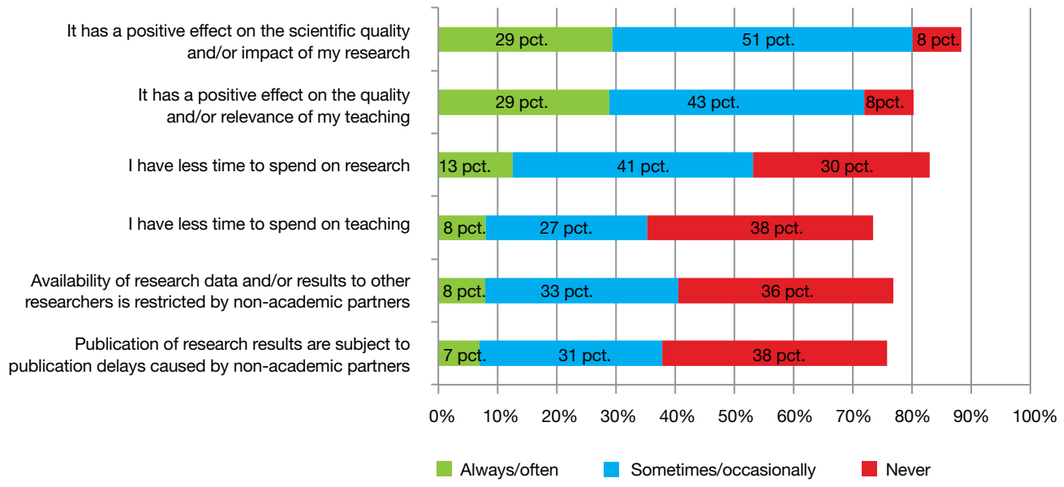
5. WHAT ARE THE CONSEQUENCES OF COLLABORATION?

This chapter focuses on the outcomes that researchers experience when engaging with the public or private sector and/or pursuing the non-academic utilization of their research. Such outcomes may be intended or unintended, and they may be viewed as positive or negative consequences by the researcher.

Researchers who have engaged in some form of collaboration with public or private sector organizations within the past three years were asked how often they had experienced the outcomes listed in figure 14.

It is noteworthy that a majority of the respondents indicated that engaging with the non-academic sector has a positive impact on research activities and/or teaching activities. More precisely, engagement "always/often" or "sometimes/occasionally" has *a positive effect on the scientific quality and/or impact of research* according to 29 and 51 pct. of respondents, respectively. Meanwhile, engagement "always/often" or "sometimes/occasionally" has *a positive effect on the quality and/or relevance of teaching* according to 29 and 43 pct. of respondents, respectively.

Figure 14. *Consequences of engaging with the non-academic sector, as perceived by researchers*



Source: DEA (2014). Survey on university researchers' engagement with industry and the public sector.. Remaining respondents answered "don't know / not relevant". N(positive-research) = 2,432; N(positive-teaching) = 2,428; N(less time-research) = 2,411; N(less time-teaching) = 2,416; N(restricted data) = 2,423; N(publication delays) = 2,428.

Box 11: What can we learn from academic research?

A large number of academic studies have speculated on or investigated the possible consequences of increasing collaboration with industry and increasing focus on patenting and other commercialization-related activities. For example, concerns have been raised that the increasing focus on patenting and the growing involvement of industry in academic research may have unintended effects on the long-term progress of science, by undermining the efficiency of the division of labor between public and private science (e.g. Cowan 2005; Nelson 1989, 2004; Feller 1990; Metcalfe 1998).

To summarize some of the main concerns are that:[30]

- Researchers will divert their resources and attention away from their main tasks (i.e. undertaking science or teaching) and towards industry-oriented pursuits (e.g. Azoulay et al. 2006; Geuna & Nesta 2006; Stephan et al. 2007; Perkmann et al. 2013)
- Researchers will shift toward more applied work at the expense of fundamental basic research (e.g. Blumenthal et al. 1996; Florida and Cohen 1999; Lee 1996)
- The openness of science will be negatively affected, e.g. by decreasing willingness among researchers to share data and/or delays in publication of research results (e.g. Dasgupta & David 1994; Nelson 1959, 2004; Geuna & Nesta 2006; Czarnitzki et al. 2011)
- Patenting of research techniques and results may limit their diffusion and use (by other researchers) as input in further research and development activities (e.g. Mowery et al. 2001; Nelson 2006), resulting in a privatization of the "scientific commons" (Nelson 2004; Heller & Eisenberg 1998; Stern & Murray 2005)

The available empirical evidence regarding the validity of these concerns is mixed. There is, however, an emerging consensus that engaging in commercialization activities, and possibly also other forms of collaboration, can (at least under certain circumstances) be associated with strong scientific performance.[31] In addition, Perkmann & Walsh (2009) investigated university-industry collaboration in engineering and found that applied (as opposed to basic) research projects can enable academics to engage in exploratory learning, which in turn can open up new research paths and projects, particularly for academics who engage in multiple relationships with industry.

So far, there appears to be little or no convincing evidence that academic research is becoming skewed towards more applied topics or that increasing involvement with industry has severely restricted the openness of science and availability of research outputs for use in further research.
See e.g. Larsen (2011) and Perkmann et al. (2013) for more detailed discussions.

30. For more information, see reviews in e.g. (Larsen 2001); Geuna & Nesta (2006); Perkmann et al. (2013).
31. For a more in-depth discussion of this issue, please refer to box 15 in chapter 7.

While there is a relatively wide consensus among respondents as to the positive consequences of non-academic engagement, there is much more variation in the extent to which individual researchers experience its negative outcomes.

Just 13 pct. of respondents indicated that engagement with the public or private sector "always/often" means that they have *less time to spend on research*, though an additional 41 pct. "sometimes/occasionally" experience this consequence.[32] Similarly, only 8 pct. of respondents "always/often" experience that engagement with non-academic actors means that they have *less time to spend on teaching*. For 33 pct. of respondents, this outcome is "sometimes/occasionally" experienced.

Less than 10 pct. of respondents consistently report that collaboration with non-academic partners leads to *restrictions on the availability of research data or results* or to *significant publication delays*.

Further analysis reveals that these negative consequences are not experienced by the same researchers,[33] but rather that different researchers encounter different negative outcomes of collaboration. This calls for further investigation of the conditions under which researchers experience such negative outcomes. For instance, are certain disciplines, types of non-academic partners or types of researchers more likely to experience negative outcomes, and if so, which?

[32] One respondent pointed out that collaboration with non-academic partners can even increase time for research, as some universities are willing to lift some teaching obligations in order to free up time for collaborative research.
[33] Just 19 researchers (i.e. less than 1 pct. of the respondents) indicated that they "always/often" experience all four of the negative consequences included in the survey questions.

Box 12: Detailed findings

This box presents findings from more in-depth analysis of survey responses. Researchers' assessment of which outcomes they experience when engaging in non-academic collaboration or commercialization activities were tabulated with respondents' university of employment, scientific discipline, academic rank and scientific performance. Relevant findings are presented below. For more details, please refer to the background report.

The number of respondents that described *a positive effect on the scientific quality and/or impact of their research* as "always or often" an outcome of their non-academic collaboration is:

- Highest at AAU (40 pct. of respondents) and at CBS, RUC and DTU (between 32 and 35 pct.), compared to 25 and 23 percent at AU and KU, respectively.
- Highest for respondents from the technical (38 pct.) and agricultural sciences (35 pct.), and lowest for the health and natural sciences (21 and 22 pct., respectively).

The number of respondents that described *a positive effect on the quality and/or relevance of their teaching* as "always or often" an outcome of their non-academic collaboration is:

- Highest at CBS (46 pct.), RUC (43 pct.) and AAU (37 pct.), and lowest at AU, KU and DTU (22, 24 and 25 pct., respectively).
- Lowest in the health and natural sciences (17 pct. for both), and highest in the technical sciences (30 pct.), humanities (35 pct.), social sciences (37 pct.) and agricultural sciences (35 pct.).

This suggests that further research is needed to explore why positive effects of engaging in collaboration and commercialization are, overall, more prominent in some universities and some disciplines.

The number of respondents that described *having less time to spend on research* as "always or often" an outcome of their non-academic collaboration is:

- Lowest for respondents from the health sciences (6 pct. of respondents, compared to 10 to 15 pct. of respondents from the remaining disciplines). This may indicate that non-academic collaboration in the health sciences (e.g. in clinical studies) is an integral part of research and therefore is not perceived as taking time away from research; it is also possible that collaborations (e.g. with hospitals) are well-established and therefore less time-consuming to establish and maintain.

The number of respondents that described *restricted access for other researchers to research data and/or results* as "always or often" an outcome of their non-academic collaboration is:

- Highest at DTU, at 13 pct. of the respondents, compared to 6-7 pct. for the remaining universities). This may be related to the high level of specialization in the technical sciences and/or significant degree of collaboration with industry at DTU.
- Highest for young researchers (12 pct. of PhD students and postdoc respondents, compared to 6 pct. of senior researchers). This finding may signal that an increasing number of young researchers are at least partially funded by external partners and presumably have had limited influence on the agreement regarding ownership and use of data produced through the research. It is also possible that they lack insight into these agreements and therefore are more concerned about potential or perceived restrictions on access to data than they need to be.

6. WHAT ARE THE MAIN BARRIERS TO COLLABORATION?

This chapter focuses on the barriers that researchers experience when engaging with the public or private sector and/or pursuing the non-academic utilization of their research.

The survey asked respondents *with recent non-academic collaboration experience* as well as those with *no recent experience* to indicate what they see as key barriers to non-academic collaboration. Responses from these two groups of respondents are presented separately in this chapter, as collaboration experience is likely to influence researchers' perceptions of what constitutes key barriers.

ACCORDING TO RESEARCHERS WITH RECENT COLLABORATION EXPERIENCE

Researchers who have engaged in some form of collaboration with public or private sector organizations within the past three years were asked to indicate their opinion of the extent to which the factors listed in figure 15 constitute barriers to collaboration.

Overall, relatively few respondents see the factors included in the survey as key barriers. Many do not recognize the factors as barriers to collaboration at all.

Nonetheless, three factors were identified as "key barriers" by approximately one fifth of the respondents with recent non-academic collaboration experience:

- *Lack of prioritization/reward from university management* (20 pct.), phrased in the survey as "University management does not sufficiently prioritize or reward such activities"
- *Conflicting timeframes (e.g. short vs. long term focus)* (19 pct.), originally phrased as "Conflicting time frames in industry (e.g. short term focus) and academia (e.g. long-term focus) make collaboration difficult"
- *Conflicting goals (e.g. profit vs. publish)* (19 pct.), originally phrased as "Conflicting goals in industry (e.g. profit) and academia (e.g. publish) make collaboration difficult".

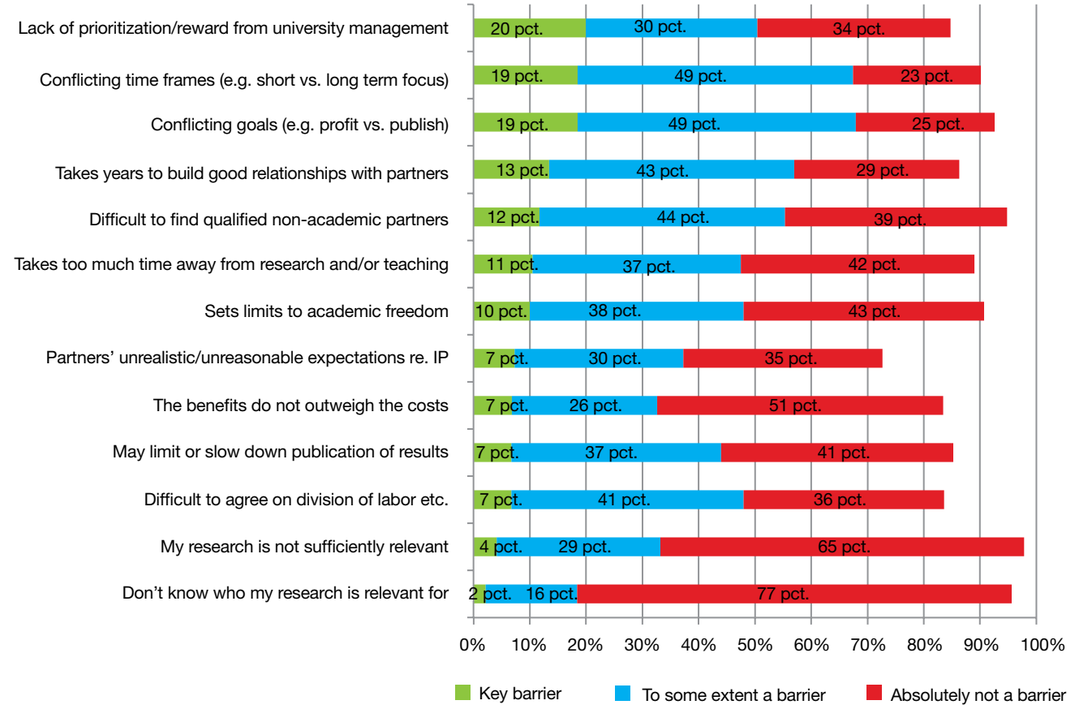
Lack of prioritization/reward from university management was indicated as a barrier by one out of five respondents with recent collaboration experience. As one respondent phrased it:

… When you establish a system where all incentives encourage you to pursue a career inside academia 100 pct., and where non-academic work experience is a disadvantage to your future research and career options, then you are left with university researchers who have limited contact to the outside world and therefore also with universities that have a tendency to close around themselves. [translated from Danish]

The latter two factors were listed as "key barriers" or "to some extent a barrier" by a total of 68 pct. of respondents, suggesting that differences in aims and time horizons are perceived as a substantial barrier to industry collaboration by many researchers. This is very consistent with findings from academic research (cf. box 13). It is worth noting, however, that approximately a quarter of respondents did not perceive conflicting goals or time frames as a barrier at all, suggesting that some researchers, some collaborative relationships, some partners and/or some areas of collaboration are not at all affected negatively by differences in time horizons or goals. According to Bruneel et al. (2010), such "orientation-related" barriers may be lowered e.g. by prior collaboration experience and trust between the partners, cf. box 13.

Interestingly, the other key barrier to collaboration which is often cited in the academic literature, that is, barriers related to intellectual property rights (IPR) protection of research results, was not identified as a major deterrent or obstacle to non-academic collaboration: just 7 pct. of respondents indicated *partners' unrealistic/unreasonable expectations regarding IP* as a "key barrier".

Figure 15. *Barriers to collaboration, according to researchers with recent collaboration experience*



Source: DEA (2014). Survey on university researchers' engagement with industry and the public sector. Remaining respondents answered "don't know / not relevant". N(prioritization/reward) = 2,337; N(timeframes) = 2,336; N(goals) = 2,339; N(takes years) = 2,327; N(find partners) = 2,338; N(too much time) = 2,320; N(academic freedom) = 2,334; N(IP) = 2,327; N(benefits/costs) = 2,330; N(limit/slow) = 2,326; N(division of labor) = 2,332; N(not relevant) = 2,344; N(who is it relevant for) = 2,344.

Box 13: What do we know from academic research?

Bruneel et al. (2010) identify two main types of obstacles in university-industry collaboration:

- *Orientation-related barriers* created by the fact that firms and academic researchers are intrinsically different in their norms and behavior (see also Dasgupta & David 1994). For example, firms often have to produce results in the short-term, while academics can work under a much longer time-frame. The two parties also have different ways of dealing with their research results: firms generally seek to protect their R&D investments by patenting valuable results or keeping them secret, while academics have an incentive to publish their findings. University researchers need to establish priority, i.e. be the first to publish key new knowledge, while firms need to turn a profit; this can be a source of conflicts.
- *Transaction-related barriers* include conflicts over the ownership of intellectual property (usually patents) developed during the course of the collaboration and conflicts over university administration and bureaucracy, which firms often cite as cumbersome.

Bruneel et al. (2010) also point to three key means of reducing these barriers. First, prior collaboration experience (especially between the collaborating parties) tends to lower orientation-related barriers, presumably as university researchers gain greater insight into industry and vice versa with collaboration experience. Second, engaging in a broad variety of mechanisms for interaction (e.g. joint research, consulting, collaboration on R&D etc.) lowers orientation-related but increases transaction-related barriers, as many mechanisms are governed by contractual relationships. Finally, trust among collaborators reduces both types of barriers.

In addition, Perkmann & Salter (2012) suggested that *how* companies (and, by extension, universities) approach collaboration can make a substantial difference to the success of the collaborations they engage in. The authors describe how firms often manage collaborations with academia on an ad hoc basis, driven by individuals rather than a coherent corporate strategy, and often on a far less professional basis than companies manage relationships to e.g. customers and suppliers. Perkmann & Salter therefore suggest that more effective, successful collaborations can be achieved by selecting the right model for collaboration, based on the aims, time horizon and degree of openness involved in the specific collaboration.

Box 14: Detailed findings

This box presents findings from more in-depth analysis of survey responses. Researchers' assessment of barriers to non-academic collaboration or commercialization activities were tabulated with respondents' university of employment, scientific discipline, academic rank and scientific performance. Relevant findings are presented below. For more details, please refer to the background report.

Generally speaking, few patterns stood out from the data. This suggests that individual researchers' assessments of barriers to non-academic collaboration are influenced by other factors that this study was unable to uncover. Nonetheless, some notable patterns are highlighted below.

The number of respondents that rated *lack of prioritization/reward from university management* as a "key barrier" is:

- Highest at CBS, AAU and AU (between 22 and 24 pct. of respondents from those universities), and lowest at DTU (14 pct.).
- Highest for the soft sciences (25 pct., compared to 16 pct. for the hard sciences).
- Highest for assistant professors (28 pct.) and lowest for professors (14 pct.).

The number of respondents that rated *conflicting time-frames (e.g. short vs. long term focus)* as "a key barrier" is:

- Highest for respondents from RUC (26 pct.) and lowest at KU and AU (16 pct.).
- Highest in the technical and social sciences (22 and 21 pct., respectively), and lowest for the agricultural and health sciences (12 and 14 pct., respectively).

The number of respondents that rated *conflicting goals (e.g. profit vs. publish)* as a "key barrier" is:

- Highest for RUC (23 pct.) and AAU (21 pct.), and lowest at CBS and AU (16 pct.).
- Highest for the humanities (22 pct.) and natural sciences (20 pct.), and lowest for the agricultural sciences (11 pct.).
- Highest for assistant professors (24 pct.) and lowest for professors (13 pct.).

The number of respondents that rated *takes years to build good relationships to partners* as a "key barrier" is:

- Highest for respondents from the technical sciences (20 pct.) and lowest for the humanities, social sciences, and health sciences (10, 11 and 11 pct., respectively).

The number of respondents that rated *takes too much time away from research/teaching* as a "key barrier" is:

- Highest at CBS (15 pct.) and lowest at DTU (8 pct.).
- Highest for the soft sciences (15 pct., compared to 8 pct. for the hard sciences).

The number of respondents that rated *partners' unrealistic/unreasonable expectations re. IP* as a "key barrier" is:

- Highest at DTU (12 pct.) and lowest at CBS, AAU and AU (4, 5 and 5 pct. respectively).

ACCORDING TO RESEARCHERS WITH NO RECENT COLLABORATION EXPERIENCE

In the last part of this chapter, we turn our attention to researchers who indicated in the survey that they have not engaged in any collaboration or commercialization activities within the past three years.

It is important to note that researchers with no recent collaboration experience are not a homogenous group. For example, this group of respondents is likely to include both researchers who for whatever reason have never engaged in any form of non-academic collaboration or commercialization activity, and researchers who have engaged in collaboration in the past, but just not within the last three years.

Moreover, there may be many reasons why a researcher has not engaged in collaboration or commercialization activities within the past three years. For instance, a researcher may be in the very early stages of a career and not yet found a good occasion to engage with the public or private sector. Other researchers may have past experience collaborating with non-academic partners, but have chosen to either stop such collaborations or put them on the shelf temporarily for e.g. personal or practical reasons.

Some researchers may avoid non-academic collaboration entirely due to personal preferences or beliefs. For example, several respondents indicated in optional comments to the survey questions that they are skeptical towards or even opposed to the idea of collaborating with partners outside academia. An example comes from a respondent, who expressed a belief that engaging with non-academic partners may have an adverse effect on university research and teaching:

My job is to contribute to basic research and to teach in a classical discipline, though preferably while providing new perspectives on both. … It would distort fundamental research and higher education if everything were to be mixed with external contacts and interests. [translated from Danish]

Whatever the explanation for the lack of recent collaboration experience, the key barriers indicated by this group of respondents are, as apparent from figure 16:

- *Difficult to find qualified academic partners* (21 pct.), originally phrased as "It's difficult to find or get through to suitable, qualified non-academic partners".
- *Conflicting goals (e.g. profit vs. publish)* (19 pct.), phrased in the survey as "Conflicting goals in industry (e.g. profit) and academia (e.g. publish) make collaboration difficult".
- *My research is not sufficiently relevant* (18 pct.), originally formulated as "My research is not (sufficiently) relevant for non-academic organizations". However, while 52 pct. of non-collaborating respondents indicated the latter as either "a key barrier" or "to some extent a barrier", another 40 pct. described it as "absolutely not a barrier".

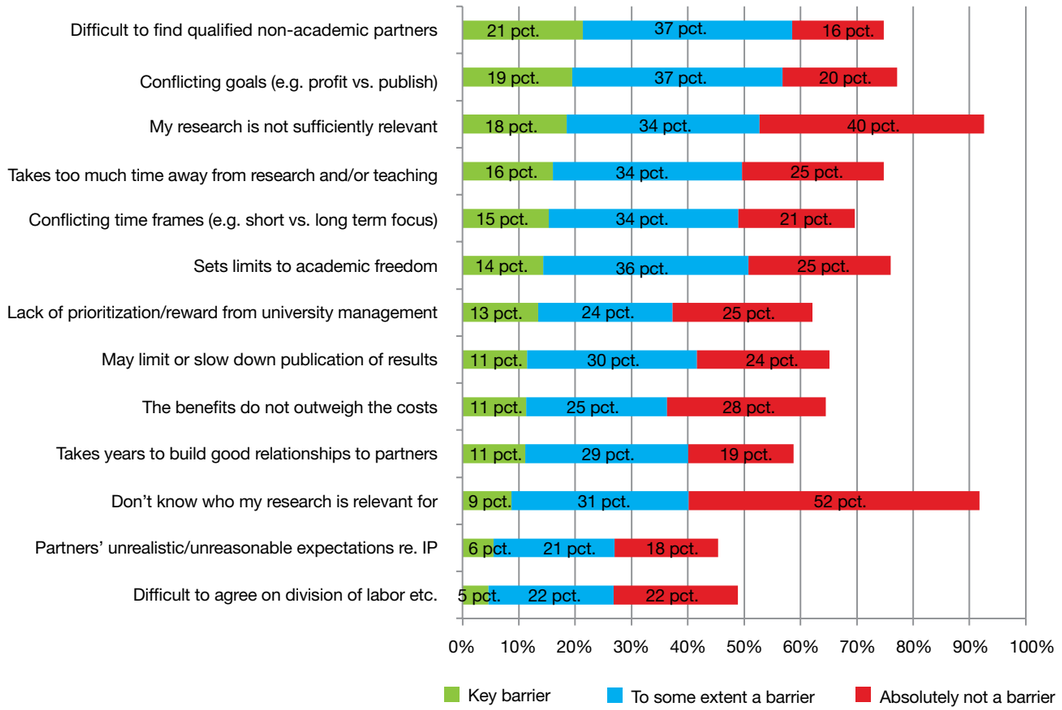
Respondents differed substantially in their assessment of another potential barrier: *I don't know who my research would be relevant for*. While 40 pct. of non-collaborating respondents indicated this as "a key barrier" or "to some extent a barrier", a majority of 52 pct. did not view it as a barrier whatsoever.

These findings underline two points made earlier, namely that perceptions of barriers vary significantly from individual to individual, and that the group of respondents who have no recent collaboration or commercialization experience are likely to be very heterogeneous and differ in several respects.

Figure 17 compares collaborating and non-collaborating researchers' assessment of which of the thirteen barriers included in the survey constitute "key" barriers to engaging in collaboration and commercialization activities.

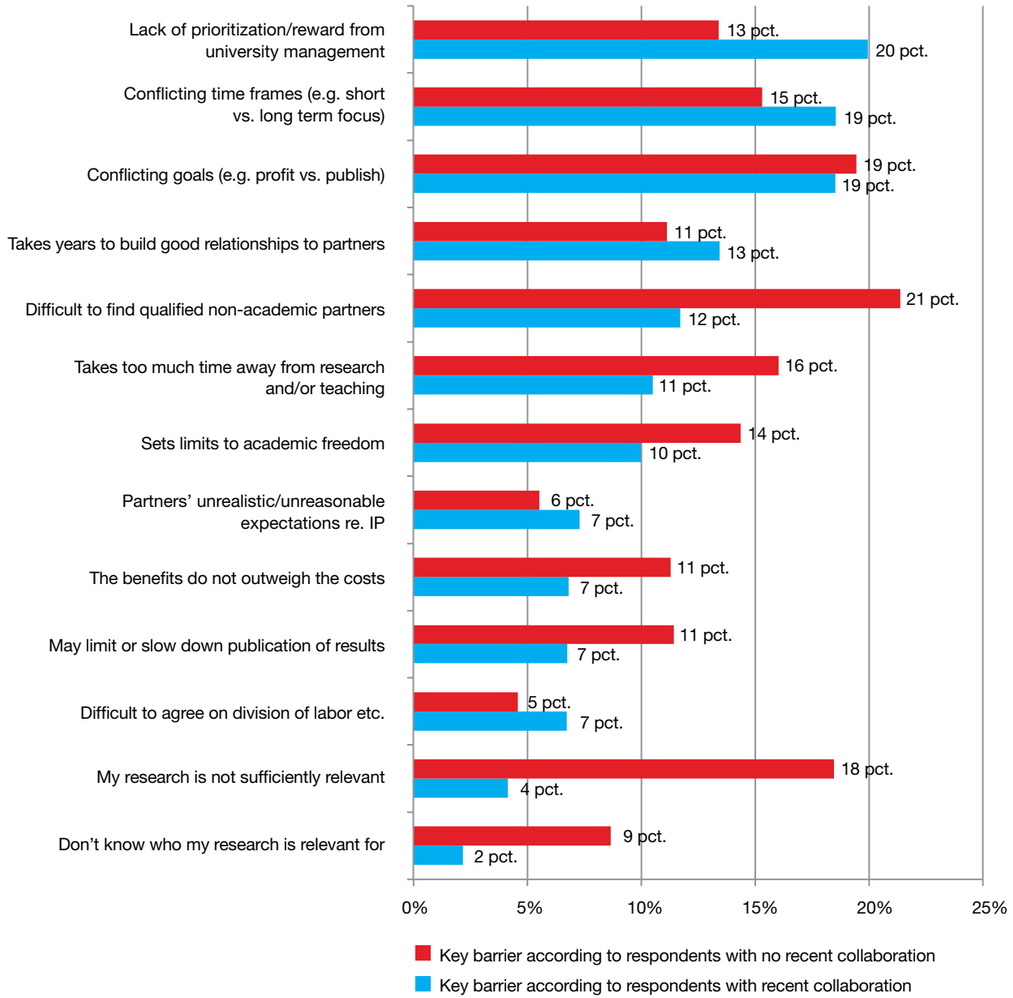
As the figure indicates, collaborating and non-collaborating researchers have the same perception of whether conflicting goals (e.g. profit vs. publish) constitute a key barrier: one out of five researchers see it as a key barrier.

Figure 16. *Barriers to collaboration, according to researchers with no recent collaboration experience*



Source: DEA (2014). Survey on university researchers' engagement with industry and the public sector. Remaining respondents answered "don't know / not relevant". N(prioritization/reward) = 784; N(timeframes) = 784; N(goals) = 787; N(takes years) = 781; N(find partners) = 786; N(too much time) = 780; N(academic freedom) = 780; N(IP) = 778; N(benefits/costs) = 779; N(limit/slow) = 778; N(division of labor) = 784; N(not relevant) = 791; N(who is it relevant for) = 785.

Figure 17. *Key barriers to collaboration according to researchers without and with recent collaboration experience*



Source: DEA (2014). Survey on university researchers' engagement with industry and the public sector. N = see figure 15 and figure 16.

Some of the points on which the two groups of respondents differ most in their assessment of the key barriers to engaging in collaboration and commercialization activities are, cf. figure 17:

- 21 pct. of non-collaborating researchers find it very *difficult to locate qualified partners* outside academia, compared to just 12 pct. of researchers with recent collaboration experience.
- 18 pct. of non-collaborating researchers indicate that *lack of research with sufficient relevance* for non-academic partners as a key barrier, compared to just 4 pct. of their collaborating peers.
- 9 pct. of researchers with no recent collaboration experience identify *not knowing who their research is relevant for* as a key barrier, compared to just 2 pct. of the respondents with recent collaboration experience.

These findings beg the question whether the variations are explained by valid differences in the researchers' research areas and the ease with which they can engage with non-academic partners, or by perceived differences caused by a lack of experience on the part of the non-collaborating scientists.

Overall, it appears that a higher proportion of researchers with no recent collaboration experience than collaborating researchers rate the listed factors as "key" barriers. This suggests that at least part of the difference in their assessment of the barriers may be explained by lack of experience with non-academic collaboration and commercialization activities.

It is also possible that some groups of researchers find it particularly challenging to e.g. identify qualified non-academic partners or build strong relationships to such partners. For example, qualitative comments provided by survey respondents indicate that certain researchers feel disadvantaged compared to other researchers. According to optional comments provided by respondents, this is for example the case for some young researchers, foreign researchers, and researchers from the dry sciences.

Finally, there are a few barriers, which more collaborating researchers than non-collaborating researchers subscribe to. For example, as evident from figure 17, 19 pct. of respondents with recent collaboration experience indicate *conflicting time frames (e.g. short vs. long term focus)* as a key barrier, compared to 15 pct. of non-collaborating respondents. Most notably, a higher proportion of collaborating researchers rated *lack of prioritization/reward from university management* as a key barrier (20 pct. compared to just 13 pct.).

In conclusion to the chapter, it is important to note that researchers with no recent collaboration experience are not a homogenous group. For example, this group of respondents is likely to include both researchers who for whatever reason have never engaged in any form of non-academic collaboration or commercialization activity and researchers who have engaged in collaboration in the past, but just not within the last three years. Moreover, there may be many reasons why a researcher has not engaged in collaboration or commercialization activities within the past three years, which may also influence his or her perception of key barriers to engaging with the non-academic sector.

7. PUTTING COLLABORATION IN CONTEXT

This survey has focused on university researchers' collaboration with the non-academic sector. As stated at the beginning of the survey, there are limitations in relying upon self-reported data, which are affected by the quality of respondents' recollection but also of their perceptions, beliefs and personal experiences. However, part of the aim of this study was to give a voice to the individual researcher, whose actions are inevitably shaped by those perceptions and experiences, whether or not they are representative or warranted. For example, several academic studies have shown that academic researchers' perceptions are key to understanding collaboration and patenting behavior in universities.[34]

We argue that it is important not to view non-academic collaboration as a distinct phenomenon, isolated from other activities that academic researchers engage in, but rather to recognize it as one of several and often highly interrelated elements of an academic career.

Moreover, collaboration with non-academic organizations is probably not necessary for all researchers to engage in, at least not to the same extent. But who *should* be engaging with industry, and what *level* of engagement is appropriate? (For more insight on the latter question, see box 15.)

KEY IMPLICATIONS AND RECOMMENDATIONS TO EMERGE FROM THE SURVEY

Based on our analysis of the survey report, we suggest some implications and recommendations for future efforts to stimulate university-industry collaboration.

Recognize the importance of informal mechanisms for collaboration and collaboration on teaching and training. Informal mechanisms for collaboration and collaboration on teaching are more common than engaging in formal mechanisms for collaboration, suggesting that more attention should be paid to the importance of such mechanisms (and the time that must be invested in them). This is particularly important as a number of academic studies[35] suggest that less formalized mechanisms of collaboration may play an important role in building and maintaining strong relationships between university researchers and collaboration partners outside academia. For example, less formalized collaboration is likely to be a precursor to formal collaboration or an important complement that helps strengthen interpersonal relationships, build trust among parties and create benefits for academic researchers and non-academic partners alike. It should be noted that we do not recommend day-to-day efforts to document and evaluate informal collaboration, as this might negatively affect researchers' motivation to engage in them.

[34]. See e.g. Tartari & Breschi (2012) who found that Italian researchers' decision to collaborate with industry is influenced by perceived threats to their academic freedom. See also Davis et al. (2011), who based on a survey of life science researchers in Denmark found that a substantial proportion of scientists were skeptical about the impact of university patenting. The authors also found that scientists who were highly productive were less concerned about the potential negative effects of academic patenting; in contrast, the most skeptical respondents were, among others, scientists oriented towards basic research (particularly the less productive ones), scientists who had previously worked in industry, and full professors. See also the review by Davis et al. (2011) of other, prior academic studies of the importance of researchers' attitudes.

[35]. E.g. Klofsten & Jones-Evans (2000); Perkmann et al. (2010); Landry et al. (2010); Abreu & Grinevich (2013).

Box 15: Evidence of a positive relationship between academic research performance and non-academic collaboration – but is more collaboration always better?

A large number of academic studies have found evidence of a significant and positive relationship between collaborating with industry or engaging in the commercialization of research results on the one hand, and academic researchers' scientific productivity (as indicated by the number of scientific articles published) and, to some extent, their scientific impact (as indicated by the number of citations to their publications), on the other.[36] In other words, researchers who engage with the non-academic world are also likely to have strong research performances.

It is important to stress that evidence of a positive relationship does not tell us anything about the direction of causality. In other words, are collaborating researchers better researchers *because* of e.g. cognitive or financial inputs derived from their non-academic collaborations, or do firms collaborate with them *because* they are good researchers? In practice, both directions of causality probably play some role in explaining the positive relationship that we see between non-academic collaboration and scientific performance.

Is the relationship between academic performance and non-academic collaboration equally strong for all researchers? There are likely to be significant differences across researchers, as most performance measures in science are skewed. For example, a small number of researchers have a high number of publications, receive many citations and attract large amounts of external funding, while a large number of researchers have fewer publications and citations and secure smaller amounts of funding. This may be partly explained by the "Matthew effect" in science and/or the existence of "star scientists".[37] It is likely that the positive relationship found in many studies between academic performance and non-academic collaboration is driven as least partly by the presence in the data of some particularly successful, visible and/or well-networked researchers. In short, we cannot expect that *all* researchers who engage in non-academic collaboration will show strong research performances.

It is also relevant to ask what *level* of interaction is desirable. Or, put differently, is more interaction with industry always better? Not necessarily. In fact, several academic studies have found evidence of diminishing returns of individual researchers' scientific productivity from collaboration with industry, or activities related to the patenting of research findings.[38] These findings suggest that there may be some optimum level of collaboration. In other words, working with industry may be highly compatible with strong research performance, but it appears that working too much or too closely with industry may be associated with diminishing or even negative impact on researchers' scientific productivity and impact.

[36]. For a review and discussion of these studies, see Larsen (2011) and Perkmann et al. (2013).

[37]. Robert K. Merton (1968) argued that psychosocial processes mean that scientists who are already successful and recognized are more likely to get credit for their contributions to science than lesser known scientists, even if their contributions are similar. He called this the "Matthew effect" to describe a mechanism of accumulated advantage by which "the rich get richer and the poor get poorer." On a related note, Lynn Zucker and Michael Darby (see e.g. Darby & Zucker 2001; Zucker et al. 1998a, 1998b, 2002) introduced the notion of "star scientists", top scientists that seem to bring a "Midas touch" to everything they work on. For example, Zucker and Darby's work has shown that star scientists exhibit both superior scientific performance and entrepreneurial performance and therefore play a key role in both the development of the science and in its successful commercialization, particularly within emerging fields of technology such as biotechnology and nanotechnology. These star scientists, while valuable assets to their departments, are not representative of the general population of academic researchers.

[38]. For a review and discussion of these studies, see Larsen (2011).

This would make such interaction cumbersome and take away its informal and often spontaneous nature. Moreover, informal collaboration is often (by its very nature) difficult to report in any reliable, systematic way, meaning that the information that could be provided through detailed reporting is not likely to be of much use. Instead, we argue that more insight is needed into how researchers make use of less formalized interaction as part of an overall effort to build or strengthen ties to non-academic partners. In addition, the potential value of investing resources in informal ties should be recognized, as informal collaboration – like formal collaboration – takes time.

Recognize differences in collaboration behavior across scientific disciplines. Much of the debate surrounding university-industry collaboration is focused on the hard sciences. Our survey results indicate that there are significant differences within the hard sciences that need to be taken into account in efforts to stimulate non-academic collaboration; thus, it is important not to treat the hard sciences as one. Second, the survey results show that many researchers from the social sciences and humanities also engage in collaboration with non-academic actors, suggesting that more attention should be paid to how these disciplines interact with their surrounding communities.

For example, our findings suggest that non-academic collaboration in the soft sciences has particular characteristics that should be taken into account. For instance, researchers from the soft sciences are more likely to be motivated to engage in non-academic collaboration in order to access contacts or insights for use in their teaching than their peers in the hard sciences. They are also more likely to identify "lack of prioritization/reward from university management" as a key barrier to engaging in university-industry collaboration, or to feel that such collaboration "takes too much time away from research/teaching".

"One size fits all"-approaches are unlikely to be effective in motivating collaboration. Survey results indicate that there is substantial variation in the extent, nature, motivations and outcomes of universities' non-academic collaboration. This variation is only partially explained by researchers' university affiliation, scientific discipline, academic rank, and scientific performance, suggesting that individual differences and other factors not covered in this survey also play a role in shaping researchers' collaboration behavior. This implies that individually tailored approaches to stimulating or rewarding non-academic collaboration are likely to be more effective than "one size fits all" approaches. At the very least, generic department or faculty-wide strategies should be complemented by a higher degree of attention to the individual researchers' collaboration motivations, opportunities and experience.

Incentive systems should be based on key motivational factors. The survey confirmed that researchers are far more motivated to engage in non-academic collaboration by expected benefits to their research and/or teaching than by formal requirements, possibilities for career advancement, or opportunities to supplement their personal income. This implies that policies and initiatives to stimulate non-academic collaboration are likely to be more effective if they highlight, and help realize, potential benefits for research and teaching activities. This may be supported by e.g. career-related benefits or explicit requirements to engage in non-academic collaboration, but such tools should not stand alone.

Build greater insight into the possible negative effects of non-academic collaboration.

Far more respondents reported positive effects than negative effects of engaging in non-academic collaboration, and few respondents experienced potential barriers to such collaboration as key barriers. Nonetheless, we suggest that it is important to gain better insight into the circumstances under which (and for whom) these negative effects and barriers emerge, in order to better support productive university-industry collaboration. This is especially relevant as our analysis suggests that negative effects were not identified by a distinct group of particularly frustrated or disillusioned researchers, but rather that different respondents experienced different outcomes and obstacles. This suggests that it is important to gain better insight into the circumstances under which (and for whom) such negative effects and barriers emerge. In terms of the key barriers identified in this study, the perceived "lack of prioritization/reward from university management" appears to be a major challenge for researchers; we will return to this point later in this chapter. In contrast, it is more difficult to say how university managers should help address the second and third most recognized barriers, namely "conflicting time frames" and "conflicting goals". According to academic research[39], such barriers are quite common, but may be reduced e.g. through greater trust between the parties and through prior collaboration experience.

Non-academic collaboration should perhaps rather be viewed a natural complement to research and teaching than as a "third mission". Referring to a "third mission" sends the signal that collaboration with industry is an extra task for researchers, which is more or less distinct from their other professional activities. However, the survey showed that the majority of respondents who engage in such collaboration experience positive benefits to their research and/or teaching. These findings stress the potential synergistic effects between research, teaching and non-academic collaboration.

The value that universities create for industry or society, which is observable and measurable in the short term is likely to be relatively insignificant compared to the long-term and often indirect value that universities create through fundamental research[40], education of students, mechanisms for dissemination of research and collaboration with non-academic actors. This suggests that efforts to boost short-term value creation should only be pursued to the extent that they do not negatively impact the long-term value which is created from society's investments in academic research, university education and collaboration between universities and industry (e.g. through public research and innovation programs that provide cofunding for public-private collaborative projects). The long-term value creation is also important from the perspective of industry, e.g. for the development of innovative products. A recent DEA study[41] showed that Danish industry tends to collaborate with university on long-term research and development projects that provide companies with qualified sparring on research that companies normally do not have the in-house competences to conduct. Collaborating firms were, in general, not looking to pick "low hanging fruits", but rather saw collaboration with university researchers as a high risk and long-term process of value creation.

39. See Bruneel et al. (2010).
40. This is due to the generic and embryonic nature of basic research (Jensen & Thursby 2001), which means that it may be decades before it is put to use in the private sector (Rosenberg 1994). Moreover, basic research rarely holds intrinsic economic value (David et al. 1994). Economic value is created when research findings are incorporated into further research and development activities in private firms, where basic research constitutes but one of many inputs to innovation (Laursen & Salter 2004). As a result, it is exceedingly difficult if not impossible to estimate the full economic value of basic research.
41. DEA (2014).

Specialization can lead to more efficient division of labor in academia but may, if taken to the extreme, negatively affect the ability of universities to realize potential synergies between non-academic collaboration on the one hand and research and teaching activities on the other. To which extent should individual researchers specialize in some of the demands made of academics today – e.g. in relation to securing external funding, teaching, engagement with non-academic actors, commercialization of research etc. – instead of trying to do them all simultaneously?

Optional comments provided by survey respondents revealed that many researchers are frustrated by what they experience as competing or even conflicting duties and expectations, especially to engage in non-academic collaboration and secure high levels of external funding, and by an increasing tendency for researchers to be "weighed and measured" using (mostly quantitative and often imperfect) indicators developed by university management and policymakers.

Specialization offers benefits by allowing individuals to focus their resources and thus supports a more efficient division of labor within the research community. If taken too far, however, specialization may also lead to an unproductive fragmentation of the community, where researchers who specialize and excel in research are likely to be seen as the "A-team", while those who specialize in teaching or in so-called "third mission" activities are likely to feel increasingly overlooked and underappreciated. Excessive specialization might also limit the extent to which universities succeed in realizing the potential synergies between research, teaching and engagement with the non-academic sector. These synergies appear to be substantial, as a majority of the respondents indicated that engaging with the non-academic sector has a positive impact on research activities and/or teaching.

This report does not conclude DEA's work on the survey data. First, we plan to undertake further analysis of the data using econometric methods in order to better understand the relationship between different factors investigated in the survey. Second, we hope that the participating universities will be open to repeating the survey every few years. We believe that a repeated, survey-based approach to document researchers' non-academic collaboration is more fruitful (and less cumbersome for researchers) than day-to-day documentation of every instance of collaboration. Moreover, we hope that more researchers will, over time, contribute to the survey, giving us a more complete understanding of the Danish research population's engagement with industry. Finally, repeating the survey would provide longitudinal data allowing us to track developments in the nature, extent and perceptions of collaboration between universities and the non-academic world.

KEY RECOMMENDATIONS FROM SURVEY RESPONDENTS

Finally, we give the word to the survey respondents themselves. We asked them what, if anything, respondents believed university management and policymakers should do to support productive interaction between university researchers and non-academic organizations. In the following, we list the main suggestions put forth by the survey respondents.

To pick up on the earlier discussion of the potential benefits and risks of increasing specialization of academic researchers, many respondents expressed an opinion that not all researchers should engage in non-academic collaboration, and a wish that such **specialization should be encouraged and rewarded**, allowing researchers to prioritize the allocation of their own resources based on personal preferences, professional strengths and opportunities. This is illustrated by the following quote:

First and foremost [engaging in non-academic collaboration] should not become yet another demand made of researchers. We should be better at differentiating between academic researchers so that those who have the right motivation and competences to engage in external collaboration are given good opportunities to do so. It should be legitimate to focus on what we each do best. We have to become better at solving the task collectively, instead of always leaving it up to the individual to fulfill all parts of the task simultaneously.

Some respondents called for **clearer (and attractive) career opportunities for those researchers who choose to specialize in non-academic engagement**. One respondent suggested creating more professorships that build on extensive practical experience, like the model of clinical professors, but adapted to other, relevant disciplines. On a similar note, another respondent suggested awarding more professorships on the basis of experience from working in or collaborating with industry.

On a related note, several respondents suggested that longer-term employment (e.g. fewer short term positions) and a higher degree of job security (e.g. more tenure track positions) would increase incentive to invest resources in building non-academic collaboration, particularly for younger researchers. As one respondent phrased it:

As a junior academic researcher I spend a lot of time and energy being concerned about job security. My research projects are relatively short-term and the focus differs according to funding sources. This … and the fact that I only know if I am still affiliated with my university/department a few years ahead, severely influences my ability to develop long term commitments … to non-academic partners.

Respondents also called for **use of metrics and (collaboration) performance assessment, which is tailored to specific disciplines and research areas**. For example, academic research has shown that consulting and contract research play a relatively greater role in the soft sciences than in the hard sciences,[42] presumably because many non-academic organizations (e.g. high tech firms) lack sufficient interest or competences to engage in actual collaborative research with social scientists or researchers from the humanities. Thus, consulting and contract research can act as an alternative or precursor to joint research projects. Similarly, in some fields, collaboration on teaching or other forms of (popular science) dissemination activities can be particularly important mechanisms for transferring academic knowledge and putting it to use outside the walls of the university. Such differences must be taken into account if and when reporting or assessment systems are developed.

Provide better incentives and/or greater recognition for non-academic collaboration. As evident from the survey, a key barrier to collaboration was a general "lack of prioritization/reward from university management". For example, effective non-academic collaboration requires flexibility and a significant investment of time and effort, as illustrated by the following quote:

[42] See e.g. Olmos-Peñuela et al. (2014).

When I get a call from a former student, who is employed in a company, then he gets a free piece of advice. If a company requests a meeting about alternative methods of [deleted to preserve anonymity], then I meet with them. If a company needs to impress a Russian customer by bringing some academic "oomph", then I'll be there. When one of my former collaboration partners calls with an urgent problem, then I pull a day out of my schedule, jump on a plane and help them. If it turns out to be a big problem that they're facing, then we'll draw the outline for a masters' thesis and recruit a student to work on the problem. That is how you create value. [translated from Danish]

The general sentiment conveyed in respondents' comments was that if university management truly wants its researchers to engage in more non-academic collaboration, the risks involved in doing so for the individual researcher must be mitigated. Ideally, engagement should generate additional benefits for the researcher. Spending time in industry or working with industry may lead to gaps or delays in researchers' scientific publication record; it may also lead to work which is published in more applied (and usually less prestigious) journals. Both of these outcomes may negatively affect researchers' chances of advancing their academic careers. Somehow, this must be addressed, though it is unclear how university managers should go about doing so.

Strengthen mutual insight and interpersonal networks between industry and academia, e.g. by promoting greater mobility between the academic and non-academic sectors, through dual positions for senior researchers or "industry sabbaticals". Several respondents called for more dual positions (similar to industrial PhDs and industrial postdocs and to the industry professorships[43] that some universities already offer), where senior researchers are hired to work both at the university and in a private firm or other non-academic organization. Such positions should be open to the researchers coming from industry as well as academic researchers willing to spend part of their work time in industry.

This would naturally require university managers to consider how dual affiliation is likely to impact how much the researcher can deliver e.g. in terms of publications and teaching, particularly if the researcher is to keep the possibility of returning to a full-time academic position open. On a related note, some respondents suggested providing better options for full-time or part-time "leaves" or "sabbaticals" which can be spent working in the private or public sector (or, vice versa, creating temporary positions to bring non-academic researchers into the university as fully-fledged members of staff).

A number of respondents pointed again to the problem that working full-time or part-time in industry for a while can have great benefits for building two-way understanding, good collaborations, and even for the researchers' own research activities, but that one is then likely to be penalized (e.g. in term of advancement opportunities) for the fewer number of scientific publications or the more applied nature of publications that are likely to emerge as a result. As one respondent put it, leaving academia for a non-academic position is (currently) a "one-way ticket". This is also illustrated by the following quote:

[43]. One researcher specifically requested offering special "Industry Chair" appointments as part of the national research grant scheme whereby upper level managers from industry can be appointed to develop knowledge exchange and collaboration around particular research themes; these positions should be co-funded by both industry and the university to ensure mutual buy-in. Finally, such appointments should be made for a minimum period of e.g. five years in order to be effective.

It is striking that the academic system is designed for people to stay there for their entire carreers or leave, but not for people trying to get into the university from the industry. For this reason … there is a great cultural gap between academia and industry – academics just don't understand how it works if they haven't been there and tend to act on the basis of stereotyped myths about how they suppose people in industry think.

Other respondents suggested other ways of strengthening mutual insight and ties between academia and industry, **e.g. stimulating increased colocation (e.g. in connection with joint projects or research facilities) and job rotations between academia and non-academic partner organizations.**

It should be easier to move in and out of positions in academia. Requirements for scientific publications today are so rigid that is difficult to get back in the game once you have been out of academia. We should be better at recognizing that academia stands to benefit from staff members with a broader set of competences and dissemination abilities that go beyond writing esoteric academic articles which, on average, are read 0.1 times. [translated from Danish]

On a related note, a few respondents suggested establishing more (attractive) full-time positions for research technicians in academia. Specialists from industry could apply for these positions, thus contributing to the exchange of knowledge and practices between academia and industry. Finally, one respondent suggested creating a new type of "postdoc"-type positions with the explicit goal of working with industry or developing ideas or technology with a view to commercialization instead of publishing; such positions would, according to the respondent, be relevant for young academics planning a (permanent) transition to industry or an entrepreneurial career.

[We should] recognise that high quality collaboration takes years to develop, rather than expect instant collaborations by throwing people in a room together. Start-up funding to build collaborations that allow for risk and failure would be ideal.

A large number of respondents called for **greater recognition that good collaborations require an initial investment of resources.** More specifically, respondents argued that productive collaboration (1) is built on trust and good interpersonal and interinstitutional relationships, (2) takes time to establish and maintain, and (3) takes time to generate publications from. In other words, university management must accept that productive collaboration requires a significant investment of time, particularly in the start-up phase but also for ongoing "maintenance". This investment of time should ideally be taken into account in the researchers' overall portfolio of activities or, at the very least, in the assessment of the output from other activities during periods of time where significant energy is spent building non-academic relationships. As one respondent put it:

… research and subsequent publication takes longer when done in collaboration with "real companies" with "real problems". By comparison, getting (e.g. research council) funding for an academically-driven project often generates more and faster publications. Good empirical data takes time to collect, validate and use, after which you need to work closely with the non-academic partner and then, eventually, try to publish your findings. It is simply a more time-consuming process.

A number of respondents requested **seed funding** to support the development of novel

(but often uncertain) interactions with non-academic partners, e.g. in the form of pilot projects. As one respondent phrased it:

Provide seed funding to allow otherwise unfunded interactions with non-academic organizations and to support pilot projects … needed to enable academics to break into new areas, and to allow academics to show potential collaborators/customers that what academics do is useful.

Other respondents lamented having to secure funding to cover overhead costs and argued that getting non-academic partners to pay for overhead costs in the university can be an obstacle when trying to establish collaborations, particularly with new partners, or when applying for grants from private foundations. One researcher suggested **subsidizing overhead costs when trying to establish new partnerships:**

One idea could be to lower the overhead costs for newly established collaborations… After all, these industry projects allow us to co-fund scientific projects for which we cannot obtain grant money. In our situation, the funds we had were almost exclusively from industry collaborations, allowing us to perform scientific projects by co-funding that now will render publications, required to improve our chances to obtain (scientific) grant money. In that respect, by lowering the threshold for (new) non-academic partners to seek collaborations with university partners, the university management invests in the future of the scientists and thereby also in its own future. … Once projects have been established, higher overhead costs for new projects or extension of projects will be less problematic once the industry partner is convinced by the quality/outcome of the current collaboration.

Many respondents, particularly young researchers and international researchers, requested **help in building insight into and networks to industry**. Concrete suggestions included e.g.

- Offering targeted courses to share good practices for collaborating with industry, typical pitfalls, and information about the kinds of expectations and time frames researchers meet from industry.
- Further encouraging student internships or projects in industry that involve direct communication between the industry partner and the academic supervisor, allowing the supervisor to build ties to potential collaborators.
- Visits to non-academic researchers at their place of work, with the aim of giving academic researchers a better idea of how industrial research is organized and what the priorities are.
- (Targeted) meeting and workshops with potential non-academic collaborators (involving both junior and senior researchers from the university), organized by university management, to discuss ongoing research, new project ideas and areas of joint interest.
- Forums for informal dialogue and networking between academic and non-academic researchers.

Several international researchers also specifically requested more English-language forums for meeting non-academic actors, as they find it difficult to build good ties to Danish companies, public institutions and media.

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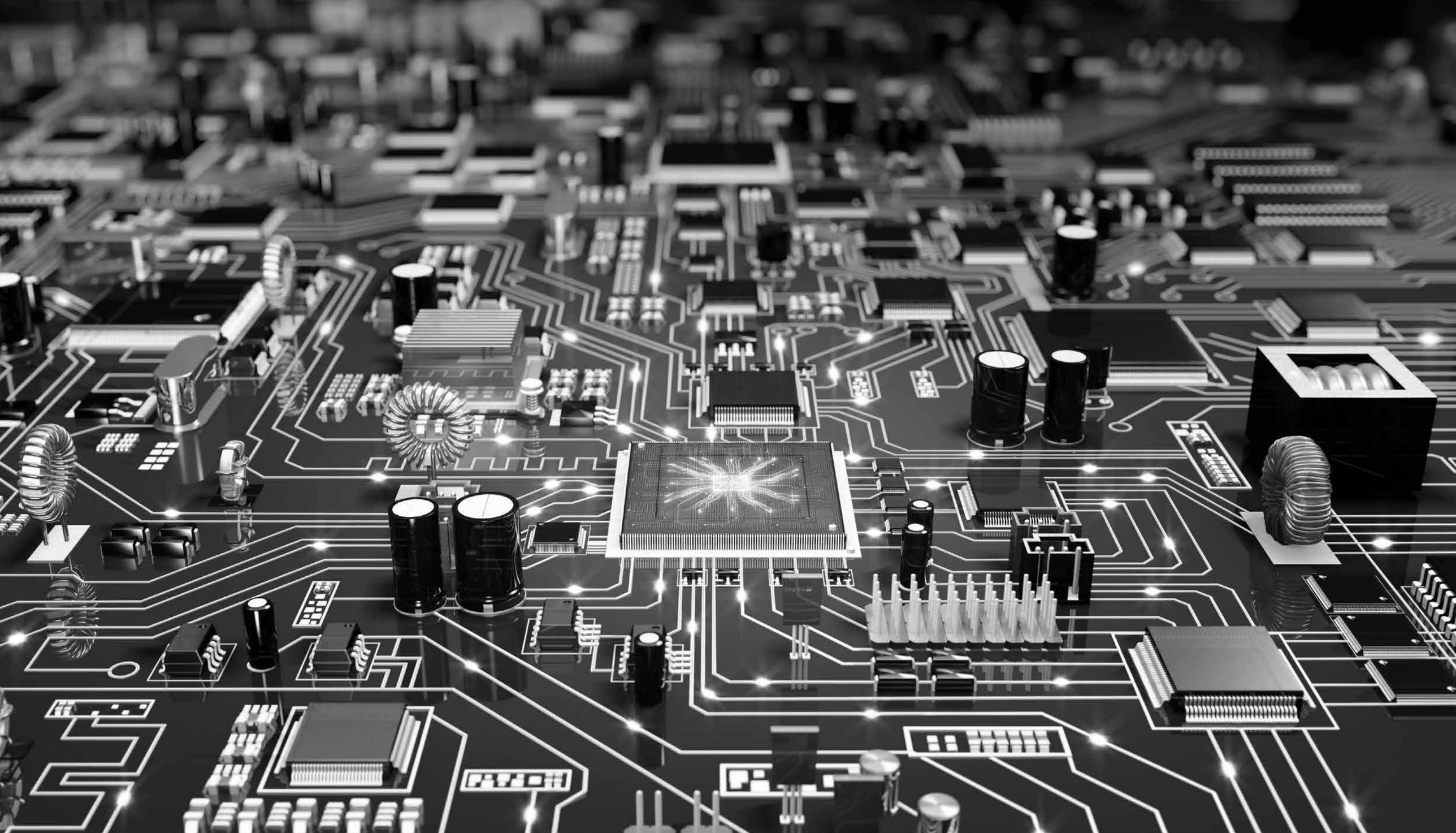

ABOUT DEA

DEA is an independent, non-profit think tank based in Copenhagen, Denmark.

Our mission is to promote intelligent and effective investments in research, education and innovation that contribute to higher growth and productivity.

DEA strive to fulfill this mission by providing high-quality research, analyses and policy advice, and by engaging in constructive dialogue with the political system and key public and private stakeholders. DEA also collaborates with relevant public and private companies to ensure that policy development is informed by needs and insight from industry.

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DEA aims to be a credible and impartial source of insight into research, education and innovation policy. To that end, we:

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- Organize conferences, seminars and workshops to stimulate informed, constructive debate and networking among key public and private stakeholders.
- Participate in the public debate regarding science, education and innovation through e.g. blogs, articles and other contributions in the media.
- Undertake selected commissioned research and consultancy projects, provided that such projects are in line with our professional and ethical standards.
- Give invited talks in Denmark and abroad.

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