Master Thesis

University-Industry Collaboration in Denmark

The Consequences of Industry-Funded Research Projects on Key University Activities - Gaining Insights From the Perspectives of Academic Researchers.

Name of Student	Anna Katharina Schroers
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Supervisor	Christoph Grimpe, Associate Professor
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List of Abbreviations

AAU	Alborg University
AU	University of Arhus
CBS	Copenhagen Business School
CRA	Collaborative Research Agreements
CSR	The Danish Council for Strategic Research
DTU	Technical University of Denmark
EC	European Commission
EU	European Union
GERD	Gross domestic expenditure on R&D
HEI	Higher Education System
IPR	Intellectual Property Rights
ITU	The IT-University
OECD	Organization for Economic Co-Operation & Development
R&D	Research and Development
RQ	Research question
RUC	The University of Roskilde
SDU	University of Southern Denmark
SME	Small and Medium-Sized Enterprises
SPIR	The Strategic Platforms for Innovation and Research
TTO	Technology Transfer Office
UI	University-Industry
UK	The United Kingdom
US	The United States

Abstract

Today's knowledge economy has increasingly emphasized the significance of collaboration between university and industry, as a means of facilitating the commercial exploitation of academic research. However, due to this rising trend academic researchers are expected to fulfill additional activities besides the more traditional functions of research and teaching, which can often cause conflicts. In this context, this study analyzes the current state of affairs of university-industry (UI) collaboration in Denmark and investigates the impact of industry-funded academic research on the performance of university researchers' core activities. For this reason, various statistical datasets and country reports are analyzed, as well as fourteen in-depth interviews were conducted during April-June 2016 among academic researchers from two Danish universities. With regard to the current extent of UI collaboration in Denmark, the data reveals that UI collaboration is a central focus in national policy-making and has gained increasing significance. Nevertheless, results indicate that the movement is still in a development phase and not yet institutionalized on the university level. With regard to the impact of industry funding on university researchers core academic activities, findings show that industrial input is predominantly perceived as positive and complementary to other academic functions. Similarly, academic researchers mention various beneficial contributions for research, teaching and fundraising activities. In contrast, negative effects are perceived to have a minor relevance for other core academic functions. However, researchers' efforts to develop preventative strategies on an individual level for effective conflict management shows that academics are well informed about conflict potential with industry, and at the same time cope with such situations regardless of institutional support structures. Overall, the results provide implications for national policy-makers focusing on the strengthening of UI collaboration and also for university management in implementing effective strategies for successful collaboration support.

Keywords UI collaboration - Conflicts of interest – Industry funding – Commercialization – Academic Entrepreneurship – Core academic activities.

1. Introduction

This chapter is the introductory part of the current study and provides the reader with relevant background knowledge on the underlying research field and research problem at hand. It contains information on the selected research approach, and on the methods used for data collection and analysis. Further, it informs the reader about contributions on theoretical, empirical and practical levels. Finally, limitations of the present research will be presented.

1.1. Problem Statement & Research Background

In today's knowledge societies, university researchers are under increasing pressure from at least three directions to actively contribute to economic growth and social welfare through the creation, dissemination and application of unique scientific findings: (1) academia, (2) industry, and (3) society. But how can they simultaneously manage the additional expectations from society with their other job-related obligations such as research and teaching? In general, are additional application-oriented activities beneficial to, or rather detrimental to the performance of researchers' job-related functions? Building on this conflict, the present thesis elaborates on the guiding research debate of how industry funding eventually impacts university researchers' core job-related activities.

The Phenomenon of University-Industry Collaboration

Over the last decades, reinforcing interactions between universities and industry have increasingly gained attention among researchers and practitioners. This was linked to a transformation of the traditional concept of 'Universities', that are now perceived to fulfill a '*third mission*' apart from their traditional core obligations research and teaching (Powell & Owen-Smith, 1998). From the university perspective, public expectation shifted from conducting *isolated* research in *ivory towers* to actively participating in the transfer of scientific knowledge to industry in order to stimulate subsequent commercialization of research findings (Etzkowitz, Webster, Gebhardt & Terra, 2000). As a result, universities increasingly serve as active contributors to the development of national economies and innovation systems (Göransson & Brudenius, 2011; Hanel & St-Pierre 2006).

In this respect, a significant amount of previous research deals with the positive aspects of collaboration in terms of related benefits and advantages (D'Este & Perkmann, 2011; Lee, 2000) that accrue to industry and academia. Some relevant examples of significant university contributions to their industrial counterparts include the stimulation of new ideas for product and process developments, the provision and training of highly skilled graduates, and in general enriching the pool of accessible scientific knowledge (Salter & Martin, 2001). On the other hand, university researchers themselves mainly benefit by gaining access to extra financial and non-financial resources (Tartari & Breschi, 2012) such as advanced equipment and technologies provided by industrial partners (Lee, 2000). Additionally, empirical evidence suggests that collaboration results in increased scientific performance in terms of research productivity, primarily measured through publications and patent records (Blumenthal, Campbell, Causino & Louis, 1996a; Guldbrandsen & Smeby, 2005), as industrial collaboration fosters new ideas for further research areas to academic scientists (Lee, 2000; Perkmann & Walsh, 2007).

However, at the core of these collaborations lies the interaction between two fundamentally distinct worlds (Snow, 1959; Schartinger, Schibany & Gassler, 2001). While industrial values are primarily based on profit-orientation and the protection of intellectual property, they strongly deviate from those of academia where scientific freedom and autonomy in selecting research agendas, and the open sharing and distribution of research results to the scientific community are highly valued (Powell & Owen-Smith, 1998; Pisano, 2010).

Following from this, there is a growing body of theory studying potential negative consequences of University-Industry (UI) collaboration, suggesting that besides those various benefits, there are several trade-offs university researchers have to agree on when deciding to engage with industry (Blumenthal, Glucks, Louis, Stoto, & Wise, 1986). Most concerns center around the fact that researchers could neglect their traditional core obligations of teaching and research in favor of increased collaboration with industry (Blumenthal, 2003). Consequently, recent studies have investigated the consequences of industry funding on academic research and especially, on the treatment of research results (Welsh et al., 2008; Guldbrandsen & Smeby, 2005). For instance, industry funding of research projects was found to induce increased patterns of secrecy and/or withholding of data (Czarnitzki et al., 2014; Blumenthal et al., 1996a), and thus, could jeopardize the openness of science. A second concern is that academics could shift their research foci towards more application-oriented topics to the detriment of more fundamental areas of research (Blumenthal et al., 1996a; Lee, 1996). Third, some studies suggest that academic researchers who work on collaborative research projects with industry show lower research performances over their career and publish less (Hottenrott & Thorwarth, 2011; Louis et al., 2001).

Despite the relatively rich research stream covering the impacts of industry collaboration on academic research output, the impact of industry funding on the teaching and education function of academic researchers has been most widely neglected among prior research (Perkmann et al., 2013). While a few studies discuss potential impacts on course development and teaching agendas on a more general level (Norris, Herxheimer, Lexchin & Mansfield, 2004; Daniels & Brooker, 2014), others discuss industry impact in terms of its contribution to the *work-readiness* of graduate students (Daniels & Brooker, 2014), by providing students with a better preparation to industrial expectations (Lee, 1996). More skeptical views suggest that professors could invest less time on teaching activities in favor for industrial collaboration (Lee, 1996, Toole & Czarnitzki, 2010).

To sum up, the available results regarding the impact of industry-funded academic research on university researchers core activities remain rather mixed than conclusive. To date, empirical investigations have failed to provide explicit evidence of the existence of either positive or negative consequences of collaboration (Perkmann et al., 2013). Additionally, there remains the question of how industry funding impacts other job-related tasks than research and teaching? For instance, how are academic's fundraising activities affected and how can they manage potential increasing administrative burdens?

1.2. Research Objectives & Research Questions

As presented above, the current state of literature regarding impacts of UI collaboration on university researchers core academic functions is rather limited and yet, failed to provide conclusive results. According to Perkmann et al. (2013): "*(...) the consequences and impacts of academic engagement need to be further explored. Extant analysis have neglected to consider its impact on educational outputs, such as time devoted to teaching, curriculum and course development, and teaching quality"* (p. 431). Thus, the present study addresses this particular research gap by contributing to the related literature on potential consequences for research and teaching activities. In so doing, the present research complements the current understanding of the phenomenon of UI collaboration in general, extends the literature on costs and benefits of industry-funded academic research, and notably investigates potential impacts on teaching activities. Motivated by the concerns among academic entrepreneurship literature regarding the potential impact of UI collaboration on key academic responsibilities, this study is rooted within an objective perspective on the phenomenon and the problem as such. Thus, it positions itself between supporting and opposing perspectives and is designed to provide additional insights into potential consequences that industry funding has on university researchers core activities.

In order to reach this goal, the scope of the study is empirically limited to the geographical context of Denmark, and in particular, to the Danish higher education system. The geographical context as such is considered as a significant factor for UI collaboration, as location-specific economic, social and other environmental factors can impact UI collaboration activities (Gál & Ptacek, 2011; Friedmann & Silberman, 2003). Thus, Denmark is considered as providing a suitable context for this topic due to two distinct reasons. First, the Danish higher education system (HEI) comprises eight universities only, which represents a manageable size for the purpose of the present study (Gregersen & Rasmussen, 2011). Second, regardless of its relatively small size, due to its strong economic performance indicators, the Danish HEI constitutes one of the top-performers in terms of innovation and research and development (R&D) among the EU countries due to its strong (Danish Government, 2016). Further, the Danish government pursues a well-established funding strategy in order to facilitate a fundamental research and innovation system and to support the country's competitive advantage through a high innovative performance (Danish Government, 2016). Within this strategy, several policy goals aim to further promote the interaction between public research institutions and industry, defined as an increase in the share of private funding (DASTI, 2014). At present, the business sector contributes with about two-thirds to the overall funding for non-academic R&D as well as investments into academic research show increasing patterns (OECD, 2016). Thus, it can be expected that the collaboration between university and industry will continuously increase in the future.

Therefore, the purpose of this study is two-fold: first, to analyze the current state of affairs of UI collaboration in Denmark by presenting the current extent of UI collaboration at Danish Universities. Findings may particularly serve to support policy-makers with an increased understanding of Denmark's UI collaboration performance; and second, revealing the potential impacts of industry funded academic research on university researchers core job-related activities, and how they manage multiple expectations simultaneously.

In the light of the contradicting literature on impacts of UI collaboration presented above and the fact that findings have significance for national governments and policy-makers to better align policy frameworks for managing UI collaboration, the researcher came to the determination of the following two research questions and related sub-questions:

- ***I. What is the current state of affairs of University-Industry Collaboration in Denmark?***
    - *In terms of research performance and external funding structures?*
    - *In terms of universities and the different scientific concentrations?*

- ***II. What is the impact of industry-funded academic research on the performance of university researchers core activities?***
    - *What are potential influences on research and teaching activities?*
    - *Do academic researchers experience a conflicting situation between individual convictions and industry expectations?*
    - *How do academic researchers personally manage such collaborative research projects with industry?*

1.3. Research Methods

In order to answer the first research question, data is collected and analyzed from several statistics and online databases including *Statistics Denmark, Danske Universiteter, Eurostat* and *the Organization for Economic Co-Operation and Development* (OECD*)*. The main focus here is to collect data on external funding structures of university research, data on collaborative research agreements between universities and industry, and giving some indication how universities internally manage UI collaboration. Additionally, country reports from the European Commission (EC) and OECD are used to evaluate the countries' policy frameworks in fostering UI collaboration.

In order to answer the second research question, investigations are primarily based on an inductive research approach (Saunders et al., 2009). In order to explore potential impacts of UI collaboration in more detail and learn from insider knowledge of participants, qualitative data is derived from conducting fourteen in-depth interviews (Boyce & Neale, 2006) with academic researchers from two Danish Universities, one with a technical/engineering focus and one with a social sciences background. The method of in-depth interviewing is based on a semi-structured questionnaire and appears as the most beneficial technique in order to gain rich insights into the experiences of involved individuals (Boyce & Neale, 2006). The reason for choosing two distinct scientific areas is related to the fact that the interaction between university and industry varies among scientific disciplines respectively (i.e. D'Este & Patel, 2007; Bozeman & Gaughan, 2007). The objective is not to look at both disciplines separately and compare findings based on their differences. Rather, motivated by the critique of Schartinger, Rammer, Fischer and Fröhlich (2002) that research on UI collaboration tends to limit its scope on a few scientific disciplines only, and thus eventually undermines the importance within other less technology related sciences, this study tries to fill this research gap by including informants from the economics/business administration field besides those from technical disciplines. Through this approach, two disciplines are chosen that are assumed to deviate within their significance for industry in order to make the results more representative for the average. Each scientific field represents an important collaboration partner for industry, but the engineering/technical sciences show respectively higher collaboration patterns compared to economics/business administration (Lee, 1996). Doing an analysis on the individual-level finds its justification in existing literature, suggesting that reflections of individuals are the core for understanding the issues related to UI collaboration (D'Este & Patel 2007; Lotz et al., 2007) and that the decision to finally collaborate is based on the individual not the faculty or university as such (Perkmann et al., 2013; Tartari & Breschi 2012). Thus, the decision to base the unit of analysis on the level of the decision-makers themselves seems reasonable.

1.4. Contributions

The relevance of the underlying research resides in revealing new insights into one geographical region, and in uncovering the impacts of collaborative projects between universities and industry on academic researchers job-related activities, which is here defined as receiving industry funding for academic research. Thus, this work contributes to existing research in the field of innovation, technology and entrepreneurship in several ways.

First, the provision of a comprehensive literature review on the phenomenon of UI collaboration, its determinants, related antecedents and consequences, results in the identification of research gaps and controversies, and helps uncover areas that need further refinement and avenues for further research. Second, the present research especially contributes to a better understanding of the consequences of industry funding on academic core activities, compared to consequences of other commercialization and entrepreneurial activities. In particular, this study extends what is already known about impacts on research activities, and especially, contributes to the scarce knowledge regarding impacts on education activities.

Third, empirical contributions are two-fold: first, European countries have received remarkably less attention in this area of research compared to regions like the US, Canada or UK (Perkmann et al., 2013). Therefore, this study has the potential to extend the empirical focus of UI collaboration by revealing valuable insights into a less-studied but relevant country, and second, by enlarging the sampling scope and including besides well-studied technological/engineering disciplines, also social sciences as one less-studied disciplinary field.

Lastly, the current research provides significant practical relevance. Especially, the findings can be relevant to policy makers and/or university administrators, in means of providing guidelines on (1) how to organize funding structures by establishing a balance between public and private funding sources, (2) how to incentivize UI collaboration successfully, and (3) how to implement effective supportive structures internally. Additionally, findings are particularly relevant to companies and their responsible managers of UI collaboration to be further informed about the needs of their academic counterparts.

1.5. Thesis Outline

The outline of the thesis is as follows: the next chapter discusses the relevant empirical and theoretical background of UI collaboration and forms the basis for the underlying investigations. The historical background of UI collaboration is presented, followed by a discussion of different channels universities can use to interact and transfer knowledge to industry. Further, the most important determinants for collaboration are presented, together with frequent motivations and benefits. The second chapter concludes by contrasting negative and positive aspects of collaboration, presenting potential conflicts of interest between the two worlds (academia vs. industry) and consequences for core academic functions. The third chapter gives describes the applied methodological strategy, and provides relevant information on data collection and analysis techniques. The fourth chapter is divided into two parts. While the first part presents the analytical results on UI collaboration in Denmark, the second part considers the results on impacts of industry funding on academic researchers core activities. Key findings are outlined and synthesized into several propositions. Thereafter, key findings are discussed in the light of their theoretical and practical relevance. The study concludes by presenting research limitations and paths for further research.

2. Theoretical Background

The following chapter generates a review on the theoretical concepts of UI collaboration in order to create the grounding for the two guiding research questions of this study. The goal is to summarize research on university-industry interaction, to reveal the actual state of affairs of underlying theories and to eventually, detect current trends, gaps and limitations within literature. The subsequent four questions are guiding the literature review:

- Why do universities and industry interact?
- How do universities and companies collaborate in terms of interaction processes and transfer channels, and what factors are crucial for 'successful' collaboration?
- What are important determinants and individual motivators to engage in collaboration?
- What are consequences and impacts of collaborative activities?

Most of the current literature has focused on the first three questions, whereas the impacts of UI collaboration in terms of consequences for key university activities, namely teaching and research are rather limited in scale and scope. Hence, the focus of the present study represents fruitful area for further empirical investigations.

Consequently, this chapter is structured as follows: first, the historical background of any links between university and industry is discussed, while further elaborating on the concept of UI collaboration more closely. Knowing the roots of UI relations and having an holistic understanding of the concept of UI collaboration is especially important to set the foundation for the first research question. Subsequently, different mechanisms and channels of knowledge transfer between university and industry are discussed, in conjunction with an elaboration of channel relevance. This is a significant step in order to classify UI collaboration and especially industry funded research projects in terms of their broader affiliation to the stream of literature on academic entrepreneurship. Thereafter, determinants, motivations and challenges of UI collaboration are discussed from industrial and academic perspectives, followed by a presentation of potential barriers and enablers for successful collaboration. The chapter concludes with a discussion on potential impacts of industry-funded research projects on university core functions like research and teaching, which also serves as starting point for the empirical investigations conducted regarding the second research question.

2.1. Historical Context of University-Industry Collaboration

Among contemporary societies science is stigmatized as playing a central role in todays knowledge economies (i.e. Machluf, 1980; Dasgupta & David, 1994; Drori, Meyer & Hwang, 2006). A central imperative within this knowledge theory is the relevance of knowledge production, described as both '*input*' and '*output*' of innovating activity (Arrow, 1962), and as being the driver of economic development and growth. Through the production, dissemination, and diffusion of innovation-related knowledge, universities can enable subsequent industrial exploitation (Dagupta & David, 1994; Mansfield & Lee, 1996), and are thus key within today's national innovation systems (Göransson & Brundenius, 2011). But the way, universities contribute to societal and economic progress today, is the result of a long-term process based on several developments and changes in the past.

Historically, academia and business organizations were regarded as two distinct worlds with clearly separated tasks (Powell & Owen-Smith, 1998; Snow, 1959). While universities contribute to society in means of *scientific research,* producing new knowledge and educating parts of the population, business focus is set on the application and subsequent commercial exploitation of knowledge, consequently, both worlds leave limited space for institutionalized interaction (ibid.). This distinction was further encouraged by the two different value systems and major cultural differences comprising both worlds (Dasgupta & David, 1994). The original properties attributed to science are '*Universalism',* recognized as the claim for objectivity and general validity, '*Communism',* seen as the perception that science as a good belongs to the public, '*Disinterestedness',* and '*Organized Skepticism'*, that is understood as science scrutinizes facts based on empirical and conclusive measures/objectives (Merton, 1973). Business organizations' value systems on the other hand, are established on profit-orientation and short-term success (Pisano, 2010). To sum up, academia and business organizations are subject to diverging reward systems where the former are guided through the pursuit of open sciences and driven by reputational gains through publications, and the latter is interested in generating profits from commercialization and thus, claims for intellectual property regimes (Dasgupta & David, 1994).

However, a few decades ago the appreciation of science experienced a shift approached by major economical, societal and political changes, helping to re-design university-industry relationships. After World War II, economical factors like increased levels of international competition for industry sectors, pushed companies towards closer collaboration with universities (Galambos, 1987). An additional observation was a shift of funding structures for public research. Whereas so far governments had provided the major funding of academic research, industrial contributions to academic research were continuously growing (Mansfield & Lee, 1996, p. 1051).

From the political perspective**,** the interdependent relationships between *science, technology* and *innovation* imposed new challenges on policy-makers to account for new mechanisms of knowledge transfer and thus, closer relationships of inter-institutional environments (Brooks, 1994). Policy-makers on national and international-levels increasingly attempted to increase innovative performance, economic growth and social welfare (Fleming & Sorensen, 2004; Geuna, 2001) through several programs and the alignment of regulatory frameworks that concern the interactive environment of education, science, and technology (Dasgupta & David, 1994; Mansfield, 1991). Other significant political developments included the enactment of specific policies, such as the US-based Bayh-Dole Act of 1980, and similar other legislations that came into effect early 2000 in several EU countries (i.e. Baldini, 2006; Grimpe & Fier, 2010; Lissoni et al., 2008; Rothaermel et al., 2007). These legislations granted universities the ownership rights over inventions that were resulting from publicly funded research. The result was a period of increased patenting and licensing activities by university employees used as a tool to secure major parts of revenue streams, and further strengthened the links between academia and industry (Powell & Owen-Smith, 1998).

As a consequence, the emerging political and economical changes press universities to reconsider internal organization and challenge existing institutional infrastructures. This is further enforced through higher pressure on universities to demonstrate their contributions and make them visible to society (Rasmussen, Moen & Guldbrandsen, 2006). As a result, many universities undertaking national study reforms of education systems (Göransson & Brundenius, 2011, p. 3) and initiate several restructuring measures (Friedman & Silberman, 2003). For instance, the internal establishment of *innovation centers* and *patenting offices* being supportive to academic researchers intellectual property right (IPR) issues (Rasmussen et al., 2006, p. 521) and to establish more holistic management systems to handle increasing collaboration with industry.

All together, the above mentioned changes facilitated the transformation from the traditional research university model, purely extending and advancing the existing stock of scientific knowledge, to an entrepreneurial model incorporating besides research and teaching also *third mission* activities into job-related activities (Etzkowitz et al., 2000; Rothaermel et al., 2007). As a result, the fact that universities participate in a variety of entrepreneurial activities has become widely accepted, having the more traditional concept of *university* transformed from being justified as an isolated entity, to expecting science becoming an integral part of society, taking over social responsibility and showing social responsiveness (Merton, 1973). In fact, collaboration activities between university and industry are considered as one of the most important mechanisms to successfully knowledge transfer, and thus, the phenomenon of UI collaboration has been widely recognized as worth studying in its diversity.

Some Evidence: Science as a Source of Innovation

In fact, various authors have already studied the role of scientific knowledge in society, encompassing a variety of perspectives from a more linear approach of scientific influence on innovation, to the more recent view of interdisciplinary and interactive learning models (Caraca, Fay & Slade, 2008). Mansfield (1991) for instance, traces social and economic benefits directly back to advances in academic research. In his study, academic research immediately promoted the development of technological innovations, which in turn increased the social rate of return through generating economic benefits in terms of increased sales volumes and cost-savings through the implementation of new processes. Contributions varied across industries, but Mansfield's overall sample of 76 major US-based companies, representing seven different industries, 11% of new products and 9% of new processes could not have been developed without the help of academic research, or at least, not with substantial delays.

Other representative examples where inventions directly emerged from advances in science are related to the early chemical and pharmaceutical industry (Furman & MacGarvie, 2007), including inventions such as the nuclear power, laser, X-rays and artificial radioactivity and their subsequent applications in medicine (Brooks, 1994). Additionally, literature within the area of biomedicine and the life science sectors lists relevant health-related and economic benefits to society from scientific research (Blumenthal et al., 1986; Blumenthal, 2003).

On the contrary, Laursen and Salter (2002) find diverging results on the significance of academic research for industrial innovative performance. They indicate that within their sample of UK-based firms, only a minority quotes university as important source of knowledge within innovative activities. With this, the authors suggest that the notion of universities being a direct source of innovation for (European) firms does not always hold, and therefore, should be treated with caution. This does not mean, that there cannot be other more subtle spillover effect from universities to firms (ibid.).

Derived from this, the general importance of academic research can vary with industry and/or technological field of application, which make it difficult to derive generalized assumptions or standardized models describing the relationship of economic performance by means of returns of academic research (Salter & Martin, 2001; Cohen, Walsh & Nelson, 2002; Bekkers & Freitas, 2008).

2.2. The Diversity of University-Industry Collaboration Channels

Being informed about the roots of UI collaboration, it is important to mention that the concept of *Collaboration* as such developed over last decades and presently embraces a diversified set of different types of university industry interactions. The differentiation between types of UI collaboration is especially relevant for the scope of this study as the theoretical concept of '*Collaboration*' is often used to describe a broad set of interactions between university and industry (Perkmann & Walsh, 2007). Following Perkmann et al. (2013), most common mechanisms of knowledge transfer that are used by today are summarized in table 1. Here, the differentiation between *'Academic Engagement'* (ibid.), hereafter referred to as *Collaboration,* and the concept of *'Commercialization'* become effective.

Table 1. Overview of Frequent Interaction Channels between University and Industry for Technology Transfer

	Collaboration	*Commercialization*
Formal:	- Joint Research (Projects) - Contract Research - Consulting - Employment & (Training)	- Patenting - Licensing - Academic Entrepreneurship - Spin-Offs
Informal:	- Networking - Conferences, Workshops - Training - Co-Publications	-

According to Perkmann et al. (2013) the two concepts need to be evaluated separately in research literature, while being fundamentally different in their orientation. While commercialization is more focused and predominantly encompasses activities concentrating on gaining financial rewards, collaboration activities are performed based in a much diversified set of objectives and can include multiple ways of engagement (ibid., p. 424).

As the focus of the underlying paper concerns industry-funded academic research projects, which fall into the category of '*Collaboration*', commercialization activities are of minor importance and thus, only discussed briefly.

Commercialization

Under the '*Third Mission*' pursued by universities, literature discusses the phenomenon that universities increasingly shift their focus from playing the sole role of scientific knowledge producers and education providers, to seek becoming active participants within the business execution of science through *commercialization* activities (Etzkowitz et al., 2000). Several mechanisms that are often mentioned within this context include patents, licenses, and spin-off companies, which are primarily transfer-oriented activities, used by universities to allocated IPR and subsequently exploit technological inventions commercially and reap financial returns (Perkmann & Walsh, 2007).

The participation of universities within such entrepreneurial activities was facilitated mainly through such enactments as the US-based Bayh-Dole Act of 1980, and similar other legislations that came into effect early 2000 in several EU countries (i.e. Grimpe & Fier, 2010; Rothaermel et al., 2007; Lissoni et al., 2008). These legislations invalidated the '*professors privilege*' and shifted the academic patent ownership to the university side. Since then, literature focuses on the emerging entrepreneurial role of universities (Rothaermel et al., 2007), in turn supporting the notion that policy-makers and university authorities are the major interest groups within this theoretical stream.

Collaboration

Beyond mainly *transfer-oriented* interactions, there exists interaction between university and industry that additionally features a high degree of collaboration based on relational aspects (Perkmann & Walsh, 2007). *Collaboration* here can be divided into contacts that are based on a high degree of formalization including contractual agreements on collaboration terms, and second, into informal contacts and conversations on various occasions (ibid.). The latter type of collaboration recently receives increasing attention by researchers, and several studies implicate that informal transfer channels are growing in relevance and importance by means of technology transfer activity (Grimpe & Hussinger, 2013; Link et al., 2007).

While formal interaction includes UI collaboration activities such as *collaborative research, joint research,* and other *consulting activities,* informal collaboration mostly occurs in the form of narrative exchanges, through networking activities, informal chats during conferences and other knowledge-intensive events, or arise through close personal ties between a researcher and a specific company (D'Este & Patel, 2007).

2.2.1. Channel Importance & Usage Frequency

Besides extensive theory on the diversity and variety of interaction channels for knowledge transfer, literature likewise discusses the respective importance of interaction channels and its determining factors. Several factors are discussed to be responsible of diverging usage patterns of transfer mechanisms (Bekkers & Freitas, 2008).

First, the relative importance of interaction channels deviates among different industries, and likewise for scientific disciplines. Schartinger et al. (2002) for instance, find joint research as of higher relevance within natural and technological sciences (here, engineering, chemistry, and physics), whereas it is not among the preferred methods for economics and social sciences.

Second, findings indicate that the choice of type of transfer channel mainly resists on the type of knowledge incorporated in the transfer (i.e. Grimpe & Hussinger, 2013). Whereas, formal contacts are mainly used to transfer codified (and explicit) knowledge, the access to tacit knowledge requires close interaction between individuals and thus, often occurs through informal exchanges based on prior relationships (ibid.).

Third, the awarded significance of interaction channels deviates between *commercialization-oriented* and *collaboration-oriented* ones. Within their study focusing on Swedish and Irish academic researchers, Klofsten and Jones-Evans (2000) receive results indicating that the main types of interacting with industry are consulting, contract research, large-scale science projects and external teaching. Patenting and licensing activities, as well as spin-off firms, were among the least carried out, which somehow contrasted the general relevance that policy-makers award to those activities. Similar results are proposed by D'Este and Patel (2007) who find the relative importance of commercial activities like patents and spin-off activities decreasing when compared to such activities like consulting, contract research, joint research and training for instance, which are much more frequently relied on by UK university researchers.

Fourth, importance can also vary between informal and formal channels. D'Este and Patel (2007) also find that informal interaction via meetings and conferences is the most common channel for knowledge exchange from a university researchers' point of view. Cohen et al. (2002) find that the most useful channel through which academic knowledge is transferred to industry are publications of academic articles, scoring 41% among respondents, closely followed by conferences and meetings, informal interaction for knowledge exchange, and consultancy activities, all ranging between 31 and 36%. Excluding consultancy, the results show that mechanisms/channels of 'open science' prevail over those that require formalized procedures. Grimpe and Hussinger (2013) on the other hand, find an interrelationship between informal and formal knowledge and technology transfer mechanisms. Their findings suggest that one does not subsequently replaces the other, but rather both should be executed simultaneously to benefit from spillover effects.

To summarize, it seems that commercialization-oriented collaboration mechanisms loose their significance, while more relational collaboration activities gain increasing importance.

2.3. Determinants of Participation in Collaboration

As seen from above, science today is perceived as being a main producer, contributor and initiator of industrial innovation and economic growth. In fact, while earlier perspectives modeled UI relationships as one-sided advantage in favor of industrial participants, today this relationship is understood as being facilitated through an interdependent and *two-directional* collaboration process where both parties benefit mutually (Meyer-Krahmer & Schmoch, 1998).

Therefore, determining factors and motivators behind UI collaboration can be discussed from a multi-level perspective of organizational and institutional determinants, as well as based on individual motivations and expectations. From the business perspective, investigations are found to focus on two different levels, namely the industry- and the company-level. From an academic point of view, key factors are distinguished on three different levels: university-wide/institutional level, the faculty level, and the individual level of the academic researcher. An overview of the most significant determinants related to each level is presented in Table 2. For the scope of this study, the industry perspective is discussed only briefly, as this study is concerned first and foremost with the academic perspective.

Table 2. Overview of Determinants from Business and Academic Perspective

<table>
<tr><th colspan="4">I. BUSINESS</th></tr>
<tr><td>Level</td><td>Industry</td><td colspan="2">Company</td></tr>
<tr><td>Factor:</td><td>• Sector
• Technology Intensity
• Competition
• Size</td><td colspan="2">• Size
• Geographical Context
• Disciplinary Proximity
• R&D Activity
• Maturity</td></tr>
<tr><th colspan="4">II. ACADEMIA</th></tr>
<tr><td>Level</td><td>University</td><td>Faculty</td><td>Individual</td></tr>
<tr><td>Factor:</td><td>• Reputation
• Geographical context
• Resource Dependency
• Policy Framework
• Age</td><td>• Scientific Discipline
• Quality
• Climate
• Size</td><td>• Gender
• Age
• Seniority
• Core Values
• Prior Experiences</td></tr>
</table>

2.3.1. The Business Perspective – Industry & Company Determinants

Industry

There are four main determinants that specify industry collaboration propensity with universities. First, several studies indicate that UI collaboration propensity varies with industry and is rather concentrated around certain groups of industrial sectors, because the relevance of scientific knowledge differs among industries (Klevorick, Levin, Nelson & Winter, 1995; Laursen & Salter, 2004). For instance, some studies suggest that academic research has a stronger role in more technology-intensive industries, such as computer/IT-businesses or engineering (Azagra-Caro, 2007), but also a central role within the emergence of the pharmaceutical sector in comparison to other industrial fields (Marsili, 1999; Meyer-Krahmer & Schmoch, 1998; Salter & Martin, 2001; Cohen et al., 2002). Although collaboration patterns among industrial sectors show higher tendencies for pharmaceutical and technology-intensive sectors, results should not be interpreted as if collaboration would always follow stringent and simple interaction patterns among industrial sectors (Schartinger et al., 2002).

Second, the overall technological intensity in certain industries is one determinant for explaining greater interaction patterns with universities (Schartinger et al., 2002). This intensity is measured based on total R&D expenditures and facilitated through higher absorptive capacity (ibid.). Also Hagedorn (1993) found technology intensity as an important factor. For firms operating within so-called *'high-technological'* sectors, R&D cooperation with other actors within their external environment is of higher importance compared to those firms of medium to low-tech sectors.

The third factor, that was found to be relevant here, is the size of an industrial sector. For instance, higher density of medium-sized companies within an industrial area, and higher dynamics of employment can positively influence UI collaboration (Schartinger et al., 2002).

Lastly, literature discusses the influence of the level of competitiveness as a potential indicator for the propensity to interact with academia. However, evidence here remains controversial. Hanel and St-Pierre (2006) for instance find that within their sample of peripheral Canadian manufacturers, the level of uncertainty associated with competitors has a negative influence on collaboration probability.

Company

Besides the relevance of industrial sectors that determine UI collaboration, additional influencing factors can be found on company-level. The size of a company matters primarily concerning differences among large, medium or small-sized firm/start-up firms as measured by number of employees (i.e. Bekkers & Freitas, 2008). Some studies suggest that large firms and start-up companies are more likely to rely on academic research (Cohen et al., 2002; Lee, 2000). Laursen and Salter (2004) disagree to these findings, and show contradictory results for start-ups, but equal ones for large firms. Schartinger et al. (2001) note that within their sample of *innovative Austrian firms*, large firms appreciate direct university contribution to internal development processes more, compared to small fellows. In a subsequent study, they highlight the significance of UI collaboration for medium firms, where a high-density of medium-sized companies in the same industrial sector is positively connected to UI collaboration patterns (Schartinger et al., 2002).

Second, the relevance of a firms' geographical context is a central point of discussion in research literature (Azagra-Caro, Archontakis, Gutiérrez-Gracia & Fernández-de-Lucio, 2006; Katz, 1994; Salter & Martin, 2001). Findings indicate that firms prefer to collaborate with universities that are located nearby. For instance, Mansfield and Lee (1996) manifested indices that US-based firms show closer interaction with US-based universities. Within their sample, only 15% of cited universities were located outside the US. D'Este and Iammarino (2010) outline similar effects among UK firms. The prevailing paradigm in literature to describe this phenomenon is the existence of a *localization of collaboration*, where firms are in an advantageous position when located close to a research universities, due to the easier access to scientific knowledge (i.e. Lee & Mansfield, 1996; Zucker, Darby & Armstrong, 1998).

Besides the significance of geographical proximity, also disciplinary proximity accounts for differing collaboration levels of firms. For instance, Meyer-Krahmer and Schmoch (1998) suggest that firms show higher collaboration propensity with universities that are from related disciplinary fields. On the other hand, literature emerging from a knowledge-management point of view suggests that knowledge proximity is less favorable for collaboration due to overlapping internal resources inducing potential knowledge redundancies accompanied by increased coordination efforts and costs (Lavie & Drori, 2012).

Fourth**,** a companies' degree of R&D activity is found to be a relevant factor of UI collaboration. Whereas, some findings find a positive and direct relationship between R&D intensity and R&D investments and the propensity to collaborate (Laursen & Salter, 2004; Kim, Lee & Marschke, 2005). Lee (2000) for instance, shows that a firm's R&D intensity negatively influences the tendency to seek for academic contributions. The rationale behind this finding is that with more R&D intensity firms most probably employ a diversified workforce of scientists' and engineers complying with their internal R&D needs (pp. 127-128).

Lastly, the role of a business' maturity in explaining UI collaboration remains unclear within research literature. Nevertheless, Schartinger et al. (2001) propose that the age of a company is a significant indicator in defining UI interactions. More specifically, their findings suggest that more recently founded companies make use of external knowledge more often compared to more established companies. Soh and Subramanian (2013) find supportive results for a mix of 222 companies from the biotechnology sector. Here, more nascent companies were in an advantageous position compared to more mature firms to benefit from UI collaboration.

2.3.2. The Academic Perspective – University, Faculty & Individual Determinants

University

The first significant factor specifying UI collaboration is university reputation**.** Mansfield and Lee (1996) explore that the most cited universities for collaboration in their sample of 66 representative US-based firms, are '*world leaders in science and technology'* such as MIT, UC Berkeley, Illinois, Stanford, and CMU. On the contrary, Lee (1996) found a negative correlation between a university's prestige and support for the objective of collaboration. This finding was supported by the fact that institutions from the middle-to-lower quality tier offer more favorable conditions in terms of UI collaboration. Also Wright, Clarysse, Locket, and Knockaert (2008) showed similar results for '*mid-range universities'* in Sweden, Germany, Belgium and UK, having a substantial amount of UI interaction

Second, the geographical area surrounding a university can determine UI collaboration. With regards to geographical context, Friedman and Silberman (2003) found especially universities surrounded by a growing technological industry in a favorable position to benefit from potential regional spillover effects and externalities from industry. Gal and Ptacek (2011) for example, note that universities located within Central European regions are in less favorable situation for UI collaboration, compared to their Western counterparts. Their sample included universities from the Hungarian and Czech region.

A third indicator for collaboration propensity is a universities' resource dependency. For instance can monetary resource constraints result into the perception of increased pressure to seek for additional external funding (Lee, 1996, 1998). This all is intertwined with governmental policies and underlying funding priorities that are shifting funding away from university research investments towards other areas, expecting universities to seek for alternative financial sources (Lee, 1996; Mansfield & Lee, 1996; McKeown-Moak, 1998), in means of universities are 'pushed' towards closer collaboration in times of declining public research funding.

Next, university transfer-oriented infrastructures are important determinants for the propensity of industry collaboration (Renault, 2006). Several authors highlight the importance of policy implementation in supporting the *new transfer role* of academics. For instance, findings suggest that university policy frameworks that reconsider the alignment of reward structures and technology transfer activities can increase UI interaction (Lee, 1996). Crucial factor here is, that transfer activities to industry and more user-oriented research that potentially results in a patentable invention, is acknowledged in the same way within academic promotion considerations as research publications (Lee, 1996). Additionally, it is relevant how universities establish internal support structures assisting academics in technology transfer activities (Lee, 2000). Internal infrastructures through the creation of university research centers (Boardman, 2008) or early establishments of technology transfer offices (TTOs) (Friedman & Silberman, 2003) can also positively reinforce interaction between university and industry.

Lastly, findings suggest that the age of a university is negatively associated to UI collaboration. For instance, Lee (1996) and Azagra-Caro et al. (2006) suggest that with age comes deeper interconnectedness to traditional academic core values, which makes universities more reluctant towards the incorporation of industry collaboration as part of their academic mission.

Faculty

In total, four main factors on faculty-level are discussed in research literature for determining UI collaboration, among which the scientific discipline is one central factor. Several studies indicate that differences in disciplinary affiliation are intertwined with different patterns of industry interaction (i.e. D'Este & Patel, 2007; Bozeman & Gaughan, 2007). According to Lee (1996) faculties from applied and those from basic science are between five and four times more likely to support user-oriented applied research compared to social science faculties, whereas applied sciences are strong supporters for the commercialization of academic research. In fact, multiple studies indicate that natural, engineering, chemical, computer and material sciences are in favor of collaboration activity (i.e. Lee, 1996; D'Este & Iammarion, 2010; Azagra-Caro et al., 2007) in contrast to members of social science and humanities faculties (Azagra-Caro et al., 2007). Schartinger et al. (2002) criticize the tendency of research literature to restrict the relevance of industry collaboration to a limited number of sciences. They show that interaction patterns are presented in an over-simplified way if limited to a few scientific disciplines. They find 10 scientific disciplines responsible for 70% of total UI collaboration, whereas beside technical disciplines and natural sciences, also social sciences such as economics were included.

A second determining factor is the academic quality of faculties that is most often appreciated through the amount of publications, engagement in commercialization and entrepreneurial activities (i.e. Renault, 2006; Perkmann et al., 2013). Mansfield & Lee (1996) find faculty quality to be a direct indicator of industry linkages. This fact does not intent to exclude 'second-tier' departments as relevant industry partners as well. Their findings suggest that contributions from faculties that 'only' rank as secondary are evaluated as valuable sources of scientific research and interaction occurs as well. This might also be related to the fact that those universities are more often smaller institutions that pursue more specialized research and thus, address industry needs that are more specific to local requirements (ibid.) Other findings indicate contrary results, suggesting academic quality is negatively correlated to interaction propensity with industry (D'Este & Patel, 2007; Ponomariov, 2008).

Third, the institutional climate among faculty members, defined as "*common exposure of organizational members to the same objective structural characteristics (...) resulting in a homogenous set of members, and social interaction leading to shared meanings"* (Ponomariov, 2008, p. 488; Schenider & Reichers, 1983) is an important variable to explain academic responsiveness towards UI collaboration. This is also sometimes referred to as the *entrepreneurial climate* that can positively impact technology transfer activities between universities and industry (Friedman & Silberman, 2003). Approval by colleagues is extremely important among scientific communities, and thus, peer pressure through other faculty members and the feeling of group norm compliances clearly impacts faculties' overall engagement with industry (Aschhoff & Grimpe, 2014; Lee, 1998; Stuart & Ding, 2006). On the contrary, findings by Guiliani et al. (2010) suggest that *peer effects* are of minor importance when determining UI collaboration.

Lastly, the size of the department can be significant in explaining UI interaction (Schartinger et al., 2001). Findings propose that explanatory significance moves along a U-shaped curve, where large and small-sized departments both have their distinctive features that bring them in a more favorable position for interacting with companies. Medium-sized departments are found to be in a less favorable position, due to disadvantages based on less flexibility and lower resource property (ibid.).

Individual

An extensively growing body of research has been conducted on studying the individual objectives that determine university researchers' engagement in UI collaborations. Indeed, Azagra-Caro (2007) finds support for the assumption that collaborative interaction is not randomly distributed among academics, but rather the probability of collaboration is facilitated through specific individual characteristics. D'Este and Patel (2007) propose that individual characteristics are much more explanatory indicators for understanding the phenomenon of UI collaboration compared to those on university or faculty level.

First, the importance of gender affiliation is discussed in research literature**.** Being a male or a female university researcher influences collaboration behavior with industry (Boardman & Ponomariov, 2009;

Tartari & Salter, 2015). Overall, current research finds a *gender gap* within collaboration (Tartari & Salter, 2015) and finds significant evidence that female researchers are less likely to engage with industry compared to their male counterparts (i.e. Haeussler & Colyvas, 2011). On the other hand, there exists also support proposing female scientists to be more likely to engage in industry relations (Guilian et al., 2010). Nevertheless, gender inequalities within UI collaboration can also often be related to an unbalanced distribution of male and female researchers among scientific disciplines (Link, Sigel & Bozeman, 2007) or within geographical regions (Azagra-Caro et al., 2006).

Second, there exists the theoretical tendency to appoint a positive relation to UI collaboration and age, in means of higher age being tied to increased collaboration behavior (Klofsten & Jones-Evans, 2000). Contrary result suggest younger researcher encounter a beneficial position for establishing UI linkages (Guiliani et al., 2010). Taking age into account, research literature also suggests that the academic status or rank of an individual, often related to the extent and duration of the prior academic career, seems to be positively correlated with UI collaboration (Louis et al., 2001; Stuart & Ding, 2006; D'Este & Patel, 2007; Boardman & Ponomariov, 2009), meaning that more senior positions are often associate with closer collaboration activities. Haeussler and Colyvas (2011) find senior researchers to be more engaged with industry, Ponomariov (2008) finds tenured academics to show higher propensity for interaction with industry. Opposing results are presented by Lee (2000) who cannot find significant data to prove seniority of being more in favor of industry interaction. Rather he suggests a reverse trend where the interest in interaction declines with hierarchical position. His explanation of this paradox is based on the assumption that at one point in the academic career, the financial capacity of a '*full professors'* might be saturated and not longer in the need for new financial funds (Lee 2000, p. 125).

Fourth, a researchers' reputation among the scientific community can also constitute a significant variable for explaining interaction with industry. Findings indicate that high-prestige scientists are those mostly exposed to interaction with the private sector (Stuart & Ding, 2006). Related findings were made by Guiliani et al. (2010), suggesting that a researchers' centrality and likewise visibility within the research community, both are strong predictions for UI interaction. On the contrary, Perkmann, King and Pavelin (2011) find that outstanding researchers from UK universities are less likely to partner with industry. This might be related to the fact that those researchers are less dependent on industrial funding to excel in their research activities and thus, incentives are limited (ibid.).

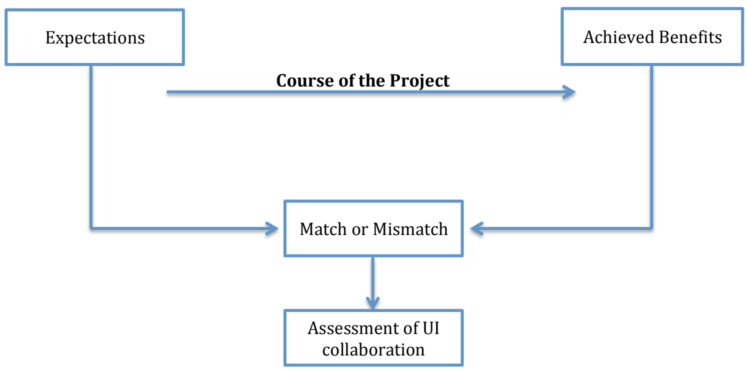
Next, the affiliation to academic core values is another factor that can influences academic researchers collaboration with industry. Strong attachment to traditional values such as commitment to academic freedom, autonomy and independence and concerns to the privatization of research can impede the propensity of collaboration (Lee, 1996, 1998). Whereas some findings suggest that the individual beliefs are the strongest predictor for a decision for or against collaboration (Renault 2006), another study suggest that internalized scientific values are not necessarily a controversy to UI collaboration (Boardman & Ponomoriov, 2009).

Lastly, the existence of prior collaborative experience and collaboration frequency are determining the likelihood that UI collaboration is intensified in the future (Lee, 2000; Louis, 2001; Olmos-Penuela et al., 2015). For instance, D'Este and Patel (2007) find a positive relationship between previous collaboration experiences and the propensity, variety and frequency of further UI collaboration. Moreover, prior industrial employment and previous entrepreneurial engagement influence academics propensity as well (Klofsten & Jones-Evans, 2000; Bozeman & Gaughan, 2007; Erikson, Knockaert & Der Foo, 2015).

2.3.3. Expectations, Motivations & Anticipated Benefits

Besides theoretical implications on the relevance of industrial and academic characteristics in determining the propensity of UI collaboration, expectations on potential benefits and achieved benefits from prior collaborations can motivate individuals to collaborate (Lee, 2000). Within this context, theoretical discussions of the concept of motivation are mainly concerned with two components: as point of departure, there are the expectations framed before the start of a project and potentially reconsidered throughout the course of collaboration, and second, achieved benefits forming the other end of the time axis, that emerge after the completion of a project (ibid.). It is assumed that a match between both objectives, expectations on anticipated benefits and actual benefits, also determines further collaboration activities. Thus, a mismatch could also constitute a turning point for collaboration (Ankrah, Burgess, Grimshaw, & Shaw 2013).

Figure 1. Conceptual components of "Motivation" for UI collaboration



Expectations & Benefits – Firms

What does industry expect from their academic partners? According to a ranking by Lee (2000), firms first and foremost aim to integrate academics into their internal research agendas with regards to R&D projects already in progress, as well as explorative research activities to initiate new products and processes. Similar results are obtained by Broström (2012) who suggests that the main rationales behind collaboration are related to support for internal '*product and process developments'* (p. 323). This is closely followed by intentions to get help with finding solutions for technical problems, and prototype development (Lee, 2000). Hagedorn (1992) finds mainly market and technology-related motives to be relevant, such as to complement ones own R&D, reducing products' time to market, and the access to markets (p. 379). This list can be complemented with other findings highlighting the value of access to human capital in means of faculty staff and students as potential future employees (Mansfield & Lee, 1996; Meyer-Krahmer & Schmoch, 1998; Salter & Martin, 2001).

What are the actual benefits that firms achieve from collaboration with university? As suggested by Ankrah et al. (2013), most cited recognitions amount to cost savings through a replacement of in-house research activities with research carried out at the university, the general enhancement of internal innovative capacities, access to the current state of research and up-to-date technologies. Salter and Martin (2001) provide a review of studies focusing on industrial benefits generated through public research. Primary benefits discusses, are summarized in six categories. First category comprises all benefits related to get access to a broader knowledge pool that is enriched by scientific research findings. The second most important factor that drives companies to collaborate with universities is the potential access to new instrumentations and laboratory equipment, as well as methodological approaches. Access to skilled graduates is one among other benefits that motivates firm's to collaborate with academia. Graduates carry knowledge about the most recent trends within scientific research and bring new ideas to the table, which can then be transferred to the company. These are followed by access to expert networks, problem solution and eventually, spin-off companies (Salter & Martin, 2001).

Overall, studies concentrating on firms' motivations and benefits of UI collaboration are scarce and not as profound as their counterparts from an academic point of view (Ankrah et al., 2013).

Expectations & Benefits – Academia

Expectations on benefits that motivate academics to participate in joint research projects with industry are mainly attributed to three job-related categories: academic research activities, educational activities, and entrepreneurial activities (Lee, 2000, p. 124). Whereas expectations on support for own research activities prevail, academics are at least motivated by prospects on entrepreneurial opportunities (Lee 2000). Additional findings point into the direction that academics can expect increased benefits from long-term projects (minimum 3-5 years), as well as from increased interaction intensity (Lee, 2000).

In general, literature capturing the academic perspective, often discusses motives in the light of monetary and non-monetary incentives. Lee (1996) for instance, finds motives for collaboration that could be traced back to two different approaches, the '*Responsibility Theory*' and the '*Utility Maximization Theory'*.

Whereas the former deals with the researchers' motivation to contribute to the freely accessible pool of public knowledge as a social responsibility, the latter theory concerns monetary incentives triggered through the demand for '*research dollars'* (Lee, 2000, p. 857). Additional motives that are mentioned include the confidence that close collaboration will positively influence economic development, revenue streams, students' training and employment positions for graduates (ibid.). Just as Lee, also Ankrah et al. (2013) distinguish between pecuniary and non-pecuniary-driven benefits framed in terms of 'Economic' and 'Institutional' features. With this distinction, they refer to the outcomes/anticipated benefits from collaboration, where 'Economic' benefits, namely the access to financial funding and the generation of business opportunities, were cited most frequently. Among the non-financial benefits, teaching related aspects appeared to be of high importance. The increase of practical relevance of course contents, the integration of real-based cases throughout lectures, and the generation of employment possibilities for graduates were cited most frequently, as well as expanding ones own network community and the stimulation of own research activities.

Related to outcomes of UI collaboration, Lee (2000) finds a positive relationship between initial expectations on anticipated benefits and actual obtained benefits, suggesting that researcher's expectations on industry collaboration are most likely satisfied. Financial benefits rank highest with access to supplementary funding, followed by benefits related to access to relevant knowledge to complement research agendas. The generation of employment opportunities for graduates and entrepreneurial possibilities were experienced as infrequent outcomes (Lee, 2000, p. 121).

2.4. Enablers & Constraints – The Origins of Collaboration Conflicts

The phenomenon of UI collaboration is subject to several enabling factors responsible for a successful performance, but at the same time, there are also some constraining factors making the research relationship more difficult. Most of restraints regarding effective collaboration between academia and industry originate from the '*two cultures'* problem (Snow, 1959; Schartinger et al., 2001). For long time, there was a clear separation between science and business, whereas "*science lived largely in the province of the university, and applications of science ("development") lived largely in business enterprises"* (Pisano, 2010, p. 469). The splitting-up of functions between the business and academic world was mainly caused through contradicting cultural value systems regarding the purpose and utilization of scientific findings (Lee, 1996; Schartinger et al., 2001). Whereas academics strive for reputational gains through open publishable results, businesses measure research outcome according to its profitability and commercial applicability (Pisano, 2010; Schartinger et al., 2001; Siegel et al., 2003). The profit versus publication aspect is just one among other factors that causes potential conflicts towards successful collaboration. Firms tendency to gain exclusive rights on valuable research outcomes often leads to issues on intellectual property rights (Hall, Link & Scott, 2001), when companies first want to withhold results to make use of them in advance of competitors. This interferes with researchers' core values of academic freedom and trustworthiness (Lee, 1996; Harman & Sherwell, 2002)**.** Tartari and Breschi (2012) for instance, find that perceived freedom restrictions are the most crucial factor when academic researchers deciding on industry collaboration. Interestingly, the same study revealed results that conflicts on IP ownership are of less importance and thus, less likely to restrain collaboration. Additional concerns related to cultural interferences are traced back to short-term vs. long-term research orientations (Meyer-Krahmer & Schmoch, 1998). In their sample of German researchers, Meyer-Krahmer and Schmoch (1998; 1997) find agreement on industrial short-term orientation being key to collaboration problems. Further, within a survey conducted by Lee (1996), respondents agreed on the objective that their long-term orientation of basic research could be threatened through increased pressure for short-term results expected from businesses. To sum up, barriers mostly fall into two categories: '*orientation-related barriers'* and '*transaction-related barriers'* (Bruneel et al., 2010). Whereas the former encompasses all conflicts related to contrasting perceptions on the expediency and utilization of scientific knowledge, the latter includes conflicts caused through administrative issues and intellectual property claims (ibid.).

Among research literature, some fewer studies exist that consider enabling factors for effective collaborations between university and industry. Suggestions reach from more prudent relationship management (Perkmann & Salter, 2012) and the establishment of trustworthy relationships (Harman & Sherwell, 2002; Mora-Valentin, Montoro-Sanchez & Guerras-Martin, 2004) to a reduction of '*orientation-related barriers*' (Bruneel et al., 2010). Other propositions concern the improvement of collaboration governance through fundamental university infrastructures (Siegel et al., 2003) for overcoming '*transaction-related barriers'* (Bruneel et al., 2010). With regards to relationship management, successful collaboration between university and industry is facilitated through trustful relationships, higher levels of commitment (Mora-Valentin et al., 2004) and communication patterns (Pertuzé, Calder, Greitzer & Lucas, 2010). Also Bruneel et al. (2010) find mutual trusting relationships as key to overcome overall collaboration barriers. With regards to university governance structures, case studies reveal that universities rely on a set of initiatives like patent offices, innovation centers, and holistic frameworks that they implement in order to support effective collaboration (Rasmussen et al., 2006).

2.5. Consequences for Universities

Simultaneously to the substantial growth of UI collaboration in recent years, concerns evolved that when academics becoming too closely linked to business objectives this could detract them from their primary academic functions of research and teaching (Blumenthal, 2003, p. 2455), and likewise happen to the detriment of the university's pursuit to *'open science'* standards (Ankrah et al., 2008, p. 55). In fact, Blumenthal et al. (1986) find research relationships with industry tend to be accompanied by several side effects for academic researchers, both positive and negative ones.

Research Activity

Discussions on potential impacts of industry funding on academic research activities mainly comprise impacts on the freedom and autonomy of academic research, impacts on scientific productivity, and impacts on research orientation (Rasmussen et al., 2006).

First, the fundament of UI collaboration is usually established on contractual agreements between industry and academia (Blumenthal et al., 1996b). This contract determines the conditions and terms of the collaboration. In fact, some studies reveal that contractual terms often restrict researchers ownership of research findings and their freedom to subsequently use them in self-sufficient ways (Blumenthal et al., 1996b; Thursby & Thursby, 2003). It is not uncommon that contracts include explicit descriptions of the expected deliverable and subsequent ownership at the end of the project (Bozeman & Gaughan, 2007).

Second, studies suggest that there might be consequences for research productivity. Positive findings record higher productivity of academic researchers who collaborate with industry in terms of publications, patenting and co-authoring of scientific articles (Boardman & Ponomariov, 2009; Bozeman & Gaughan, 2007). Also Hottenrott and Thorwarth (2011) show that a higher proportion of industry research grants within the overall research budget are positively associated with increased quality and amounts of publication output. Thus, the authors conclude that at the present extent of UI collaboration, policy-makers would not need to concern industrial funding as a significant threat to scientific knowledge remaining a collective propoerty (p. 1599). A contrary perspective suggests an adverse relationship between research productivity and obtaining industry funding (Louis et al., 2001). For instance, Blumenthal et al. (1996a) indicate that with an even higher share of industrial funding to total funding (in this case, 2/3rd being funded by industry), the lower the amount of publications and their quality, in means of publishing less influential articles (Blumenthal et al., 1996a). Nevertheless, within the area of nanotechnology no results were found that indicated any relationship between private funds and scientific productivity (Beaudry & Allaoui, 2012). In summary, findings for scientific productivity remain inconclusive and mixed.

A second stream of studies deals with concerns on openness of research outcomes. This is supported through observations regarding increased levels of secrecy over research findings and delays of publication (Blumenthal et al., 1986). In a subsequent study, the same authors (Blumenthal et al., 1996a) repeated their research design. Meanwhile, the overall share of industry support for academic research had increased and their study suggested similar results. Additional findings indicate decreasing communication patterns of researchers receiving private funding, in means of executing higher secrecy over their research findings towards academic colleagues. In another study, Blumenthal et al. (1996b) state that companies often include terms in contractual agreements that require university researchers to withhold information for at least six month, in order to gain additional time to file a patent. Additional studies on secrecy are manifold. Louis et al. (2001) suggest that researchers involved in collaborations with industry, and those receiving higher shares of industry funding, are more likely to treat their research secretly and withhold findings from colleagues. Similarly, Czarnitzki et al. (2014) propose a higher likelihood to refuse colleagues requests when researchers received industry funding for their research. In another study, Czarnitzki et al. (2015) compare the sharing behavior of researchers receiving external funding in general, with those receiving exclusive funding from industry. The authors report an increased likelihood to restrict the sharing of research findings by either deferring data publications or keeping them secret. Conclusively, there are consistent concerns and findings that industry funding can be responsible for delayed research publications and thus, can jeopardize the open-science paradigm.

A third direction of research expresses concerns on impacts on academic research direction and/or orientation. Findings suggest, that academic research could become restrained by industrial benefactors in terms of freedom to select research topics (Blumenthal et al., 1986). As a result, research agendas could shift towards more application oriented topics. For instance, Blumenthal et al. (1986) noted findings on the reconsiderations of research projects towards commercial applicability when industry funding was involved. Regarding re-considerations of research projects and research direction, also Dooris (1989) finds some evidence. His findings suggests that a re-orientation of research agendas on behalf of university-industry collaboration occurs simultaneously with a shift of funding structures, from public to private support.

Teaching Activity

As already presented in subsection 2.2.3. on expectations and benefits of collaboration, an important driver for academic researchers to collaborate with industry are expected benefits for their teaching activities. Important examples include the increase of practical relevance of course contents, the integration of real-based cases in lectures, and the generation of employment possibilities for graduates (Ankrah et al., 2013). In fact, Lee (1996) investigates that academic researchers who do not expect any harmful impact strongly support the opinion that industrial collaboration is essential to enrich educational content with real-world problems and also helps students to find better job opportunities after graduation (p. 858). Some studies even suggest that industrial inputs are purposefully integrated into course curricula, as being essential for preparing graduates for their future *employability* within industry (i.e. Daniels & Brooker, 2014; Tymon, 2013). On the other hand, concerns remain that industrial collaboration could be accompanied by a general decrease in teaching quality, in particular, negatively influence the quality of PhD theses, and that less time could be devoted to teaching (Lee, 1996, p. 858).

Bozeman and Boardman (2013) provide a positive outlook for UI collaboration in their study where they cannot find indicators that increased level of industry involvement impedes with researcher education mission. Rather, findings suggest that industry involvement is positively connected to undergraduate teaching involvement, and general support for all-level students. Based on their research results, they conclude that it cannot be expected that academic researchers would execute more market-oriented activities to the detriment of their educational mission (Bozeman & Boardman, 2013, p. 115).

As presented above, most studies present academic researchers' expectations of cost and benefits resulting from industry funding, but what are actual consequences for teaching activity? Here, research is scarce and remains inconclusive.

Fundraising

Research on how industry funding influences proceeding fundraising activities and the composition of future funding structures, is mostly neglected. As indicated by Mansfield and Lee (1996), when industry funding increases, and governmental funding decreases, this might lead to an unintentional misallocation of financial resources for R&D, as some research institutions might be in an advantageous position over others regarding the contributions of industrial funding and also collaboration with industry. Thus, it is necessary to get informed on potential consequences of industry funding in order to align policy frameworks accordingly. With researchers competing for financial benefactors, it could be assumed that some researchers are in more favorable positions or fulfill better quality criteria towards others in gaining access to funding sources (Grimpe, 2012). This could be for instance through their affiliation to specific universities, faculties, and/or through individual factors such as reputation or research productivity (ibid.). But how does the granting of industry funding in the past, in particular affects funding structures and fundraising activities in the future? This area of research has been mostly neglected in current literature.

2.6. Conclusion

The literature background has provided the reader with some relevant background knowledge on the phenomenon of UI collaboration. We have learned that university and industry collaboration as such is not a new phenomenon. However, recently this phenomenon has been reshaped and more narrowly defined, enforced through several political, economical and organizational changes. Today, UI collaboration is appreciated as multi-dimensional phenomenon facilitated through various channels of exchange, ranging from mainly transfer-oriented mechanisms like patents and licensing, to those emphasizing relational and collaborative objectives. The significance of each channel depends on various factors such as industry and/or knowledge characteristics. An important insight here is that academics favor knowledge transfer channels of closer collaboration over those of pure commercialization orientation. This points to the significance to focus research on UI collaboration modes compared to those mechanisms often stressed in politics like patenting and licensing.

Further, it has been found that multiple factors are determining the propensity of collaboration. Most significant determining factors on the industry level as well as on the academic level include geographical, technological, competitive and disciplinary aspects.

Next to the determinants, firms as well as academics are driven by a multiple set of motivations that induce them to engage in collaboration activities. It is found that expected benefits often correspond to anticipated benefits, which is in favor for subsequent collaboration. On average, advantages are perceived as a more critical factor to UI collaboration from the academic perspective, compared to potential disadvantages, which implies that collaboration also increases despite perceived limitations (Meyer-Krahmer & Schmoch, 1998).

Finally and to sum up the section on potential consequences of industry funding on university researchers core academic activities, so far research has not reached a level of consensus regarding either negative or positive consequences, and results remain scarce and fragmented. Nevertheless, what can be extracted from research literature is, that impacts on research activities have been discussed more thoroughly than impacts on other activities such as teaching and fundraising. With regard to research, there exist discrepancies between those suggesting positive spillover effects, and others that express negative concerns. Whereas, the former position focus primarily on research productivity, the latter stream of literature focuses mainly on potential trade-offs for the openness and freedom of research activities, and the shifting of research agendas towards more application-orientated topics. Findings on consequences for teaching activities remain scattered, leaving space for further investigations in this area of research.

To conclude, despite all concerns on the integrity of industry funding on academic research, joint collaborative projects have continued to emerge and are expected to further flourish in the future. Thus, the need to further investigate the impacts of industry funding on university traditional mission still exists, and becomes even more justified given the fact that UI research formations are increasing in number and variety.

3. Methodological Framework

The following chapter illustrates the methodological framework of the present study. Methodology was chosen accordingly to the two-fold research objective: first, in order to describe the current state of affairs of UI collaboration in Denmark, and second, to explore the impacts of industry funding on academic researchers core university activities. In a first step, the chosen research approach and its purpose are elaborated, followed by presenting the research design. Thereafter, a description of the data collection process is provided, eventually passing on to an explanation of data analysis techniques. This chapter concludes by discussing the quality criteria and potential delimitations of the underlying methodological approach. As research methods deviate with respect to the two-fold research objective, subsequent sections describe approaches separately whereas the methodology in line with the second RQ constitutes the main focus.

3.1. Research Method

The research methodology of the present study is primarily based on inductive reasoning and is concerned with qualitative data (Saunders, Louis & Thornhill, 2009). Based on a phenomenological research approach (Moustakas, 1994) for gaining deeper insights into the phenomenon of UI collaboration, the methodology is in line with the researchers' underlying epistemological stance of *Constructivism* (Guba & Lincoln, 1994). According to Schutt (2012) this paradigm shares the "*belief that reality is socially constructed and that the goal of social scientists is to understand what meanings people give to that reality*" (p. 86). The individual is in the center by generating a micro-level perspective on a specific phenomenon, whereas data is of non-statistical and subjective nature (Cohen, Manion & Morrison 2007). Furthermore, this belief allows for the co-existence of multiple realities, which are subjectively constructed by individuals in their current social context, and knowledge creation happens through an inter-play between the researcher and the participants (Guba & Lincoln, 1994). This perspective is likewise reflected in the primary qualitative data collection method of in-depth interviewing (Gray, 2014), where the researcher actively takes part in the knowledge generation process through interactively exchanging, interpreting, and expressing real-world perceptions with the participants during the data collection process. Grounded in phenomenology, this study explores aspects of the phenomenon based on lived experiences of involved participants and focuses on generating new theoretical knowledge by understanding the meanings individuals attach to this experiences (Moustakas, 1994). Descriptions of involved individuals on their experience are regarded as fundamental in *"understanding human behavior and as evidence for scientific investigations*" (Moustakas ,1994, p. 21).

3.2. Data Collection Process

The research objective of the current thesis is based on two guiding research questions, making it necessary to consider data collection processes separately. Within an early phase, a diversified set of secondary data was gathered to generate a better understanding of the underlying context and to collect relevant data to answer the first research question. This method as described by Saunders et al. (2009, p. 262), obtains data mainly from documentations or surveys already performed and used for its initial purpose by others. Thus, data can be comprised of numerical as well as of written information (ibid.). An interesting aspect within this approach is that secondary data sets from different sources can be combined, and eventually result in new meanings and understandings (ibid.). The data accessed to answer the first RQ was mainly based on Denmark and thus, concentrated on one empirical context. Although several agencies, public institutions and government departments publish their internally-generated reports, the access to relevant information can be challenging, especially, because the multiple-source character makes screening and sourcing efforts complex and time-intensive. First, data on the Danish innovation and R&D system was collected from different sources such as national policy documents and country reports provided by the *Danish Ministry of Higher Education and Science, The Danish Agency for Science, Technology and Innovation, OECD,* and *the EU.* Here*,* the goal was to generate a clearer picture of current political frameworks and initiatives regarding innovation, R&D and education, and eventually, find out about the central strategy imperatives concerning UI collaboration. Additional statistical data was accessed online through the website of the state-based institution *Statistics Denmark*, and supplemented with data provided by the organization *Danske Universiteter* (Universities Denmark) situated in Copenhagen, Denmark. The latter source is the responsible body for the coordination and cooperation of all universities in Denmark , and provided data supported primarily a better understanding in terms of the current *status quo* at Danish universities in terms of interaction with industry. Thus, the purpose of data collection at this point was two-fold: first, it served to create a profound understanding of the research context, and second, to elaborate on the current state of UI collaboration at Danish universities.

In a subsequent phase, the data collection process was mainly concerned with conducting qualitative research to investigate the second RQ. Within social sciences, qualitative methods define one way to collect or analyze non-numerical data (Saunders et al., 2009, 151) and can include materials such as interviews, field observations, case studies, questionnaire responses, or other narrative documents (Strauss, 1987). An essential feature of qualitative data is that while often data sets are comprised of smaller groups of respondents, the generated information therefore is very rich in detail (Cohen et al., 2007, p. 461). General criticisms on qualitative studies claim that samples sizes are often too small to have representational characteristics and to provide generalizable results (Hycner, 1985). Additionally, findings can rely heavily on subjective interpretations from the researcher and thus, could be subject to personal biases (Strauss, 1987). However, the qualitative approach was chosen in accordance with the research objective, namely investigating the phenomenon of UI collaboration whereas the presence of industry funding was of central meaning. Thus, studying the phenomenon through descriptive accounts of lived experiences and perceptions of involved actors was the central point of investigation, which could mostly benefit from qualitative research. Data collection followed now a more concentrated approach by collecting data through the method of in-depth interviewing (Boyce & Neale, 2006). The interviews were conducted with respondents from two Danish universities who had existent experiences with industry collaboration, literally were already engaged in research projects directly funded by industry. The in-depth interviews are very valuable in terms of phenomenological research (Gray, 2014) as they enable the researcher to collect rich pools of detailed information on a particular phenomenon. However, the interviewer must be continuously aware that answers can include personal biases (Boyce & Neale, 2006). Interviews are one of the very time-demanding techniques for data collection, but group interviews seemed to be inappropriate, as the topic was regarded as being somehow sensitive and confidential (Boyce & Neale, 2006). Confidentiality and anonymity were guaranteed to the interviewees (Saunders et al., 2009, p. 180), but were not as much of a concern as data analysis is independent of individual or organizational names.

The overall purpose of this study is therefore not to derive generalizable results that subsequently account for general validity, but rather to generate additional insights into the topic to contribute with new theoretical knowledge, and eventually, derive a set of ideas and propositions that can guide further research in this area. The main focus was therefore set on behalf of the university actors, and somehow disregarding the role of industrial participants. The reason behind this is first, that there is only a limited number of studies available that capture the micro-level perspective of academics, and second, that the researcher of the current study is a student, which leads to a closer relationship to the university and a higher probability to gain access to potential participants for the study (Saunders et al., 2009, p. 176).

3.3.1. Sampling Criteria

To derive an appropriate sample for the interviews, the researcher has the choice between *probability sampling* and *non-probability* methods (Saunders et al., 2009). Whereas in the former method every entity in the sample has the same probability to participate and is especially appropriate for quantitative studies, the latter allows the researcher to select participants based on subjective judgment (Saunders et al., 2009). The sample of this study was selected *purposefully* and on a *non-probability* basis (Patton 1990), with the aim to find "*information-rich cases for study in depth"* (p. 169). As the unit of analysis was composed of individuals, namely academic researchers who fulfill the criterion of have been engaged in industry funded research projects, the question was *where to find a sample best representative of the targeted population*?

Subsequently, two universities were selected as providing a relevant pool of potential participants. The rationale behind this was two-fold. First, preliminary theoretical insights about UI collaboration revealed the fact that interaction patterns differ among scientific affiliations. Whereas some scientific disciplines are of higher relevance for companies with regards to technology and innovation-related knowledge, other disciplines are more inapproachable to industry (D'Este & Patel, 2007). Concluding, that the rationales behind engaging in UI collaboration may deviate, it could be expected that experiences of collaboration projects also differ. For this reason, two academic institutions were selected of being representative of distinct academic fields, namely Denmark's Technological University (DTU) representing various disciplines within engineering and natural sciences, and the Copenhagen Business School (CBS) mainly offering programs in the social science area like economic and business administration. This selection was evenly supported by information gained through data collection for the first RQ. Statistical data provided that the technical university was the one with the highest collaboration activities in Denmark, whereas the Business School is at the lower end of collaboration activity in Denmark but showing an increasing tendency. More information on both institutions can be found in a table in Appendix E. Important to mention here is that the research objective was not to conduct a comparative study on how the impacts of industry funding differ between two distinct scientific disciplines. Rather, the two scientific areas were selected based on the assumption that they differ in their significance for industry, and that finding similarities between the two consequently leads to a more solid understanding of potential impacts.

As a result, the sample is expected to represent a somehow heterogeneous cross-sectional sample of university researchers at Danish universities, capable of *maximal variation* (Patton, 1990, p. 172), as the sample allows to minimize potential biases by including cases commanding broad and rich experiences with the topic (Patton, 1990), combined with examples from less experienced areas. Nevertheless, some biases can be expected related to researchers intensity of past experiences with industry. It can be expected that researchers that have multiple experience of research collaboration have different opinions than those that have participated within one or only a few projects. Also, it could be possible that opinions diverge when the respective project was sometime in the past, compared to a participant describing experiences on a current or recently finished project. Concluding, due to this multi-stage process of sample selection, the procedure is rather a combination of multiple purposeful methods, than following one specific technique (Patton 1990).

Recruitment

First, for the DTU the recruitment process was done via searching on the university website (www.dtu.dk) and related departments. Departments were selected after screening the department's website on information about involvement in university-industry collaboration. Correspondingly, a list of several hundreds of researchers was created who were affiliated with university departments actively engaged in industry collaboration. The list included information on tenure status, departmental/scientific affiliation, and mail addresses. A pre-informational email was randomly send to all identified individuals, including details on the researchers personal background and personal motivation for the study, as well as providing information on the broader research topic not going too much into detail or revealing interview questions. The pre-condition of have been engaged in UI collaboration and of having received industry funding as a qualifying criteria for the interview was also highlighted in the E-mail.

For CBS the recruitment process was more complicated compared to DTU. As UI collaboration is not such a common phenomenon at CBS, the Dean's Office of Research was contacted first, being one responsible office in coordinating collaborative agreements between CBS and industry. The response included the link to a website providing a detailed overview of university-industry projects at CBS, including information on participants, as well as on funding sources. Subsequently, a list of potential researchers from CBS was created based on the information of the online overview. This list was quiet short and included around 25 researchers. Later on in the recruitment process at CBS, the researcher could take advantage of recommendations from other academic researchers.

The initial plan was to conduct 10 interviews in order to keep the data amount manageable. After conducting the tenth interview there were still new aspects introduced during the conversations. Therefore, the decision was made to conduct additional interviews until the point of data saturation (Saunders et al., 2009, 235) was reached. After fourteen interviews, topics were repeatedly emerging from the data and hence, additional data collection stopped. This decision is based on a general rule on sample size suggested by Boyce and Neale (2006) that once similar *stories, themes and issues* emerge during the interviews then an adequate size of the sample size could be expected (ibid., p. 4).

As a result, the final sample consisted of fourteen university researchers, whereas seven researchers were working at DTU and seven at CBS. A sample overview is provided in Table 3.

Table 3. Sample Overview

Participant	Gender	Academic Status	University	Disciplinary Field
#A	Male	Associate Professor	DTU	Technical/Engineering
#B	Male	Associate Professor	DTU	Technical/Engineering
#C	Male	Associate Professor	DTU	Technical/Engineering
#D	Male	Professor; Head of Department	DTU	Technical/Engineering
#E	Male	Associate Professor	DTU	Technical/Engineering
#F	Male	Professor	DTU	Technical/Engineering
#G	Male	Professor; Education Coordinator	DTU	Technical/Engineering
#H	Female	Research Assistant	CBS	Economics & Business Administration
#I	Male	Professor (with special responsibilities)	CBS	Economics & Business Administration
#J	Male	Professor	CBS	Economics & Business Administration
#K	Female	Professor	CBS	Economics & Business Administration
#L	Male	Professor; Head of Department	CBS	Economics & Business Administration
#M	Male	Professor	CBS	Economics & Business Administration
#N	Female	Assistant Professor	CBS	Economics & Business Administration

All participants share the characteristic that they have been involved in some collaboration projects with industry, have received industry funding at least once, and pursue teaching and research activities at their institution. Differences were found in the diversity and extent of past experiences with industry, including researchers with single experience and some with multiple projects. The majority of respondents were male researchers, while the sample unintentionally comprised only three women. Interestingly, the respondents had different nationalities and are not all Danish citizens. Half of the sample had a Danish nationality, while the other seven were coming from six different countries respectively. The individual nationalities are not stated here, in order to protect the identification of each respondent. As individual cultural values can influence an academic researchers' mindset towards UI collaboration (Renault, 2006), it is an important fact to mention here that the sample might thus, not be representative for Danish academics. However, all researchers are part of the same higher educational system and institutional regulatory framework, and it can be expected that their experiences with industry are exposed to similar conditions.

3.3.2. Interview Framework

For the purpose of this study, semi-structured interviews were conducted (Saunders et al., 2009, p. 320). This type of interview consists of a set of guiding questions, but still includes enough flexibility to react to emerging topics during the conversation process. The questions were framed in an open-ended way (Boyce & Neale, 2006, p. 5) to provide interviewees with sufficient flexibility how to build up their answers (Saunders et al., 2009, p. 337). Sometimes follow-up questions were asked that were more specific, whenever participants' contributions did not lead to substantial, information-rich answers. Although, question sequence was not always followed up on a strict order, rather pro-actively approached during the interviews, the same topics were discussed in all conversations. The interview questions were developed after a preceding literature review on UI collaboration. A detailed interview outline is provided in Appendix B and the final interview guide is presented in Appendix A. All interviews were conducted under similar conditions via Skype.com and recorded where given anterior consent of the interviewee (Saunders et al., 2009, p. 190). The selection of Skype as the appropriate way to run the interviews was mainly based of timely and locational constraints and provided a very inexpensive way for direct communication and video conversations online (Cohen et al., 2007, p. 242). On the other hand, this method contains the risk that some interviewees do not feel themselves comfortable talking online instead of face-to-face (Saunders et al., 2009, p. 350). For that reason, an introductory mail was sent including background information on the interviewer and field of research, the purpose and scope of the project, and some general information on the topic. The interviews were primarily conducted in English, except two interviews that were conducted in German in order to potentially benefit from convenience effects of communicating in the native language.

While the recruitment process already started in late March/early April, the ultimate interviews took place over a period of one month, starting late April and ending early June. On average, the length of the interviews is 45 minutes, while they are ranging from 30 minutes to 1h 15 minutes respectively.

Initially, one trial interview was conducted in order to check precision and relevance of questions and topics, to eventually resolve potential misleading aspects. Since the trial interview did not reveal any contradictions, it was included within the overall sample used for this study. Further, the integration of probing questions came into play in order to clarify ambiguous statements, and to ensure that statements were understood in the right way (King & Horrocks, 2010, p. 53).

However, the performance of interviews was subject to at least one limitation. Interviews can be supplemented by meanings of nonverbal communication (Onwuegbuzie, Leech & Collins, 2010). As all interviews were conducted via Skype, nonverbal communication in terms of body language and emotional expressions could not be regarded to their fullest extent. Nevertheless, voice variations as volume, silence and tone, could be taken into account, as well as accentuations.

3.4. Data Analysis Approach

In order to answer the first RQ, choices were made about what was relevant to include with regard to answer the first RQ and to present appropriate contextual data for the grounding of the second RQ. Data was accumulated from reports and statistics and merged into practical overviews on UI collaboration activities at each of the eight Danish universities, as well as information provided on funding sources of research.

Prior to the data analysis for the second RQ, all interviews were manually transcribed by the researcher. The subsequent analysis of the interview transcriptions followed the principles of the template analysis approach presented by King and Horrocks (2010, p. 166), likewise suitable to the constructivist perspective (Brooks & King, 2012)**.** This technique allows for creating a *template* that helps the researcher "*organizing and analyzing qualitative data*" thematically, by identifying emerging patterns and relationships between data units (Brooks & King, 2014, p. 4). At the end of this process, this template presents a list of all themes and codes in a hierarchical order that emerge from the qualitative data and which were identified by the researcher (ibid.).

One central aspect within this technique is the permission to develop an *initial coding template,* based on codes and themes that the researcher already identified in advance, based on his/her pre-existing knowledge on the topic (Brooks & King, 2014). This element is a distinctive feature to other qualitative data analysis methods, as it allows the researcher to be more flexible within the development of the coding process (ibid.). Preliminary frames, ideas or theories can be included as helpful starters within the analysis path. This is especially relevant in cases, where the researcher has no purely open-minded relation to the underlying data set, but potentially has already developed a pre-conceptualized mindset (Brooks & King, 2012). Within this approach, *a priori themes* (Brooks & King, 2014) are at no point recognized as fixed, but rather as *tentative* constructs that can continuously be revised and reframed through subsequent iterative cycles of interaction and comparison with additional qualitative data. At the end, this method results in a *final template*, which is based on the complete data set (Brooks & King, 2014). Afterwards, the researcher can use this *final template* as assistance within the interpretation process.

Procedure of application

The analysis procedure within the present study was conducted as follows: first, the researcher read through all interview transcripts in order to get familiar with the textual data. Then the process of *tentative coding* started by drawing from pre-existing ideas and knowledge on what could be relevant topics for answering the research question and related sub-questions and based on the structure of the interview questionnaire. Guiding themes and topics were impacts of industry funding on academics' research, teaching and fundraising activities, as well as individual perceptions describing the situation as conflicting or non-conflicting. With this in mind, additionally preliminary coding was conducted based on one interview that appeared to contain very rich and relevant information from the engineering/technical sciences. Subsequently, an *initial coding template* was created containing several levels of main categories, guiding the further interplay of the researcher with the data, and to be tested on the remaining interviews. During the continuous application of the initial template, the different categories were adjusted as soon as new and relevant themes were identified in the data. This procedure was repeated over and over again, until no new themes or codes could be identified that appeared to be relevant to answer the research question. The final themes, categories and sub-categories that are guiding the analysis process are presented in Table 4. The final template cannot be presented in the scope of this study as it is too extensive, but the *initial coding template* is presented in Appendix C respectively, to communicate an idea of the researchers thoughts to the audience.

Table 4. Themes and categories guiding the analysis part of the 2nd RQ

Theme	**Category**	**Sub-Category**
I. Impacts on Core Academic Activities	Research Activity	• Quality • Orientation • Productivity
	Teaching Activity	• Quality • Relevance • Development
	Fundraising Activity	• Access • Composition
	Administration	-
II. Perception & Management of Situation	Conflict vs. No Conflict	-
	Preventative Strategies	• Balancing Strategies • Selection Strategies

3.5. Quality Reflections

Qualitative phenomenological research is subject to several limitations and it is critical to reflect the quality of the underlying research regarding its methodological appropriateness. Therefore, this section discusses issues on the *generalizability*, the *reliability* and *objectivity* of phenomenological research findings, primarily concerned with the main qualitative research method of in-depth interviewing. Although scholars cannot agree on a standardized approach for the application and usage of quality criteria, (King & Horrocks, 2010, p. 158), there is a general agreement on the importance of using any criteria to reflect on potential quality issues.

Limitations of qualitative research methods are often discussed in the light of the *generalizability* of research results (Boyce & Neale, 2006; Saunders et al., 2009, p. 327). Drawing conclusions from a small sample only, does not allow for transferring meanings to the entire population. Additionally, context-specificities diminish the probability to find similar results in another geographical, social or organizational context. This is clearly a drawback of the present study. Nevertheless, results serve as being "*phenomenologically informative*" (Hycner, 1985, p. 295) and should be thus rather regarded as stimulating ideas for further research and creating new theoretical inputs. Additionally, research findings are later on compared to existing theories, and through this relationship-building attempt, results have the chance to demonstrate their significance in a theoretical context (Saunders et al., 2009). Furthermore, the scope of the present study is limited to Denmark at the geographical level, and with this, there is no claim to generalize results across country boundaries but eventually, they find significance in other geographical contexts that are similar to Denmark (Guba, 1981, p. 81),

The reliability of qualitative research is often a concern among researchers (Saunders et al., 2009, p. 326). Especially, the missing standardization within semi-structured interviews can cause concerns about the *reliability* of the data (ibid.). Within this context, the problem of *objectivity* is often mentioned, as data is always subject to subjective interpretations and influences (ibid.). When compared to quantitative methods, only a limited set of instruments is available to support qualitative research, and hence, the researcher herself is central within the data accumulation process, subsequent analysis, and interpretation (Guba, 1981). Thus, problems of objectivity can be aroused, as individuals might be biased and results are rather based on subjective assumptions (Guba, 1981). The issue with *subjectivity* in diminishing the *replicability* of the whole research process and eventually, restrains other researchers from deriving the same results (Hycner, 1985). The phenomenological researcher of the current study addresses this issue by facilitating external comprehension by presenting an accurate and detailed description of the research process, making respective decisions more transparent (King & Horrocks, 2010, p. 161).

Within the context of *reliability,* another limitation is discussed. Several biases can occur, whereas two main types of bias are mentioned frequently: (1) '*the interviewer bias'*: the impact that the researcher exerts on the participants; (b) '*the interviewee bias*': the impact that the participant exerts on the researcher (Saunders et al., 2009, p. 326). In order to check for potential inconsistencies during the interviews, either related to minor quality of recordings (King & Horrocks, 2010, p. 144), or caused through language barriers and interpretation errors, the respective transcription was returned to the participant to offer the chance to reread the interview (Saunders et al., 2009, p. 485) and give some feedback (King & Horrocks, 2010, p. 163). Although not all transcripts were returned, this was one attempt to increase the accuracy of results.

3.6. Summary

The present study has a two-fold research objective by investigating first, the current landscape of UI collaboration in Denmark, and second, potential impacts of industry-funded research projects on university researchers core activities. For the first RQ, a multiple set of statistical as well as textual data was obtained through national databases and published country reports. For the second RQ, research methods were mainly guided by phenomenological premise and qualitative data was selected through fourteen in-depth interviews to gain in-depth knowledge on the phenomenon of UI collaboration through detailed descriptions based on the experiences of involved actors. The interviews were based on a semi-structured questionnaire and were conducted among a set of fourteen academic researchers from two Danish universities, namely from the Technical University of Denmark (DTU) and the Copenhagen Business School (CBS). The combination of informants from technical/engineering and social sciences in the sample is regarded to help to lift up the relevance of research findings to a higher level of significance.

The design of the phenomenological study is subject to several limitations primarily caused through the qualitative nature of data und related methods. With regards to the final composition of the sample, it is limited to a quite small number of participants caused and the eventuality in selecting the sample can be questioned. Further, the interviewing and subsequent analysis are exposed to the researchers subjective influence, which limits the probability that other researchers can replicate the research and deriving to same results. In order to diminish underlying quality concerns of qualitative research methods, the researcher provides a detailed and holistic description of the underlying research process in order to uncover to the reader how results were derived.

4. Analysis

The following chapter outlines the data analysis based on the methodological concepts outlined in the previous chapter. In alignment with the two guiding research questions defined in the introductory part, this chapter is split into two parts. The first part of this chapter describes the analyzes of country reports on Denmark and statistical datasets obtained through online databases, in order to derive results that answer the first RQ:

I. What is the current state of affairs of University-Industry Collaboration in Denmark?

This is done by providing a comprehensive framework of the national research and development (R&D) and innovation strategy, current national regulatory and political initiatives concerned with facilitating the interaction between universities and industry, a description of Denmark's higher education system informing on the eight Danish universities, and a presentation of data on expenditures for R&D and resulting external funding structures of public research.

The second part of this chapter outlines the analysis of the qualitative data gained through the interviews with fourteen Danish researchers in order to present the results concerning the second RQ:

II. What is the impact of industry-funded academic research on the performance of university researchers core activities?

Here, the analysis process is guided by the three formulated sub-questions: (1) *What are potential influences on research and teaching activities?* (2) *Do academic researchers experience a conflicting situation between his/her individual convictions and industry expectations?* (3) *How do academic researchers personally manage such collaborative research projects with industry?*

As a summary of each section, key findings are aggregated into the formulation of a set of propositions providing answers to the two guiding research questions, and to be point of departure for further investigations in this area of research.

4.1. Status quo of University-Industry Collaboration in Denmark

Current research on UI collaboration has provided different approaches to measure the scope of the phenomenon. Prevalent approaches and indicators include measurements of (1) the share and increase of industry funding of public R&D compared to total R&D expenditures; (2) number of co-authored papers from academic and industrial researchers; (3) licensing activity and related income; (4) and amount of patent application, which does not necessarily require prior collaboration but can be an indicator (i.e. Crespo & Dridi, 2007; Turk-Bicakci & Brint, 2005). Nevertheless, there is still no standardized approach how UI collaboration should be measured systematically (Perkmann et al., 2013), and attempts do not extend the aforementioned approaches. Thus, the subsequent analysis relies on existing measures but beyond this, seeks to extend existing measures. Therefore, additional data on open external research projects, numbers of newly signed collaboration agreements held by the Danish universities, and types of collaboration channels in use in Denmark are included. The aim is to sensitize further research to the fact, that usual measures should be extended and further strive for a unified measurements.

4.1.1. The National Research and Innovation System

Overall, and as part of the *Europe 2020 Strategy*, Denmark has formulated its target to achieve and keep R&D investments up to a level of 3% of national GDP (Danish Government, 2016). In order to comply with this goal, Danish authorities have implemented several reforms and initiatives that support the achievement of this goal (ibid). Within the overall R&D investment target of 3% of GDP, the national target regarding government spendings on R&D is set to contribute with at least 1% of GDP to overall R&D investments (Danish Government, 2016). For the creation of a successful allocation strategy of public funds, the government is engaged in the obtainment of relevant knowledge on the effectiveness of current research efforts. One central objective is to stimulate the collaboration activities between the universities and the industrial sector, especially with national companies. Therefore, the government encourages the Danish universities to systematically organize their internal research activities, through strengthen their self-financing performance through enhanced commercialization activities and fundraising from the private Danish sector (Danish Government, 2016).

In terms of research performance, Denmark ranks high in terms of productivity of scientific publications, and simultaneously meets high quality standards as Danish researchers rank among the top three OECD counties of most cited scientists (Danish Government, 2016, p. 44). In terms of Innovations performance, Denmark ranks among the top four performing and thus, belongs to the leadership group of the EU Member States of the European Innovation Scoreboard 2014 (EC, 2014).

Major National Support Programs for Research and Innovation

In order to facilitate national innovation and research performance, Denmark has implemented several support programs whereas each has a slightly different objective (DASTI, 2014). Some of the major support programs implemented throughout the last years are presented below:

- *Danish Council for Strategic Research*

  The Danish Council for Strategic Research (CSR) promotes outstanding research that has societal and economic relevance. Thus, CSR primarily supports research within the private and public sector that addresses current national challenges. Therefore, the council offers of several programs, for instance *the Strategic Platforms for Innovation and Research* (SPIR). The main objective of SPIR is to enhance strategic research and innovation linkages and by this, supporting the dissemination and subsequent application of innovation-relevant knowledge (DASTI, 2014).
- *Industrial PhD*

The Industrial PhD is an important program that further strengthens the knowledge exchange between universities and businesses, by offering a student the opportunity to conduct research within a real-life setting (DASTI, 2014). Thus, underlying research moves closer to practical relevance and application-orientation.

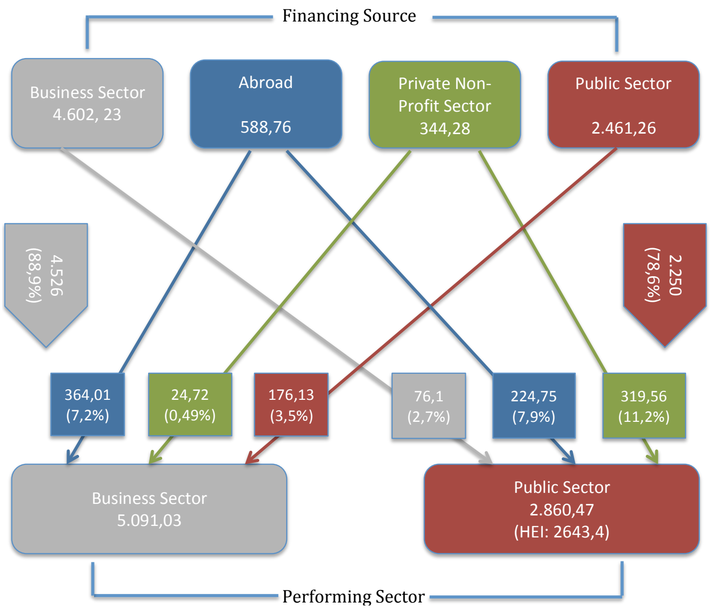
- *The Danish National Advanced Technology Foundation*
  The Danish National Advanced Technology Foundation is an important institution that provides financial support and framework conditions for the private and public sector working on significant technological developments. Through this support, the foundation aims to further enhance national growth and employment opportunities (DASTI, 2014).
- *Innovation Network Denmark (The National Danish Cluster Programme)*
  This program in particular facilitates the creation of Innovation Networks. Innovation Networks are cluster organizations that consist of all relevant universities and other technology organizations that share expertise within on particular technological field. Within each innovation network, academic and industrial researchers work together on innovation projects and try to find solutions for specific technological issues. Overall, innovation networks are another initiative to support knowledge transfer between national firms and research institutions (DASTI, 2014).

Overall, findings suggest that the Danish support system for innovation and research is quite successful and fulfills its objectives by facilitating collaborating firms to increase their productivity level by 2.5 % over the two years following the collaboration project (DASTI, 2014).

4.1.2. R&D Funding in Denmark

Overall, R&D investments amounted to around 7.951,52 (Mio. €) in 2014 (EUROSTAT, 2016) and Denmark's overall gross domestic expenditure on R&D (GERD) increased from 2.5% in 2007 to around 3.05% of GDP in 2014 (OECD, 2016). Thus, Denmark complies to the *Europe 2020 strategy* targets of keeping R&D investments up to at least 3% of GDP. With these performance indicators Denmark is well above EU 28 average, and ranks among the top five countries of all EU Member States in terms of R&D expenditure relative to GDP. As can be found in Figure 2, contributions of the business sector to the national R&D system commonly exceed those of the public sector by constituting $2/3^{rd}$ of total investments, but, business sector funding for public sector research only amounts to a small proportion of around 2,7% (76,1 Mio. €).

Figure 2. R&D Expenditures by Financing Source and Performing Sector, 2014, (in Mio. €)



(Source: EUROSTAT; OECD, 2016)

As can be found in table 5, the share of business sector investment remains mainly unchanged showing a slightly decreasing tendency throughout the last years. Government investments into R&D are continuously increasing and mostly responsible for the growing share of R&D expenditures of GDP. However, government contribution slightly underscores the national target of reaching 1% of GDP funded by the government, but as data indicates there is an increasing tendency. Since 2010, whereas data on Finland indicates declining investments since 2009, and also Sweden's total R&D spending are somehow stagnating (OECD 2016).

Table 5. GERD 2009-2014, split by industry and Government contribution, in % as of GDP

	2009	**2010**	**2011**	**2012**	**2013**	**2014**
Total	3,07%	2,94%	2,97%	3,00%	3,06%	3,05% ©
Industry	1,91%	1,79%	1,81%	1,80%	1,77%	1,77% ©
Government	0,80%	0,83%©	0,84%©	0,88%©	0,93%	0,93% ©

©: National estimation

(Source: OECD 2016)

4.1.3. The Main Performers of Public Research – The Eight Danish Universities

Since the mergers in 2007 of public research institutions with Danish universities, the current Danish higher education (HEI) system encompasses eight full universities (Gregersen & Rasmussen, 2011, p. 290). *The University of Copenhagen* (KU) which was founded in 1479, and presenting Denmark's first university, offers a comprehensive range of scientific areas for research and studying, as well as *The University of Arhus* (AU) and *The University of Southern Denmark* (SDU), which was created in 1998 by a merger between the university of Odense and a business school located in the Southern part of Jutland (ibid.). The other five remaining universities are somehow more specialized in nature regarding their research and educational orientation, and include *The University of Roskilde (RUC)*, *Aalborg University (AAU)*, *The Technical University of Denmark (DTU),* which was established in 1829 and initially entitled *The College of Advanced Technology,* as well as *The Copenhagen Business School* (CBS) and *The IT-University* (ITU) (ibid.). Table 6 provides an overview of the eight Danish universities based on their main scientific discipline-foci and in terms of their size and age.

Table 6. Overview of the sample of eight Danish Universities

	Humanities	Social Sciences	Technical/ Natural Sciences	Health Sciences	Students (2015)	Employees (2015) (full-time equivalent)	Foundation
KU	+	+	+	+	40.486	10.139	1479
AU	+	+	+	+	36.517	7.866	1928
SDU	+	+	+	+	~22.700	~3.200	1998
RUC	+	+	+	-	8.000	1.000	1972
AAU	+	+	+	-	15.963	3.307	1974
DTU	-	-	+	-	10.631	5.832	1829
CBS	+	+	-	-	22.829	1.759	1917
ITU	-	-	+	-	2.474	310	2003

(Source: Gregersen & Rasmussen, 2011; Baldini ,2006; respective website see 7.1.)

Funding Structures at the Eight Danish Universities

Denmark's funding system for university research is two-fold: internal funding or '*basic grants'* that are assigned directly to the universities by several national ministries, and external funding that comes for instance from the national research councils, EU programs, private foundations, or directly from private companies (Strehl, Reising & Kalatschan, 2007). Whereas the universities are more independent on how to use the former category of grants, as they are not attached to any particular research purpose, the latter are more directly tied to intended research usage or specific research projects (ibid.).

Overall, industry funding of university research shows varying patterns over the last years as presented in Table 7. Considering the period of 2007 to 2014, overall industry funding for academic research increased and has more than doubled between 2007 and 2014. This development indicates that industrial sectors searching increasingly access to academic research via R&D funding and also, this points into a positive direction for increasing UI collaboration in Denmark. However, when considering the share of business sector funding for academic research, than there is still a lot of growing potential.

Table 7. Share of Industry-funding of total R&D expenditures at Danish HEIs, 2007-2014 (in Mio. €)

		2007	2008	2009	2010	2011	2012	2013	2014
Higher education sector	Total R&D Expenditures	1.550	1.821	1.959	2.150	2.254	2.401	2.594	2.643
	Recieved by Business Sector	31	(n.a.)	70	67	77	65	65	67
		2,00%		3,57%	3,12%	3,42%	2,71%	2,50%	2,53%

(Source: EUROSTAT; OECD, 2016)

The following table gives an overview of all external research funding sources received by the eight universities, considering all data in constant prices. This is according to data from 2014 and in the brackets the numbers of the year 2007 are included in order to make funding amounts comparable. *Basic grants* are purposefully excluded, as only external funding is relevant for the scope of this study.

Table 8. External Research Funding Sources by University as of 2014 (2007), in 1.000 DKK

	National (Danmark)		**International**		**Total**	Change of total funding amount in %
	Public	Private	EU	Other		
KU	1.115.181 (683.164)	742.762 (310.672)	244.613 (130.565)	152.998 (60.340)	2.255.553 (1.184.740)	190
AU	930.487 (702.636)	427.326 (299.930)	152.153 (113.566)	57.961 (104.363)	1.567.927 (1.220.495)	128
SDU	300.049 (164.486)	201.299 (115.094)	64.023 (44.185)	32.534 (18.097)	597.905 (341.862)	175
RUC	65.610 (71.819)	13.936 (6.301)	10.099 (9.717)	5.323 (3.556)	94.967 (91.392)	103
AAU	385.406 (137.806)	101.468 (52.923)	60.106 (49.409)	25.019 (10.774)	571.999 (250.912)	228
DTU	924.143 (577.842)	279.662 (140.400)	282.937 (172.515)	137.915 (88.092)	1.624.657 (978.849)	166
CBS	44.969 (44.987)	31.008 (26.522)	19.366 (9.864)	3.778 (777)	99.122 (82.150)	120
ITU	19.010 (7.657)	1.711 (3.582)	6.128 (848)	580 (-)	27.429 (12.086)	227
Total	3.784.855 (2.390.397)	1.799.172 (955.424)	839.425 (530.669)	416.108 (285.999)		
Change of funding source in % from 2007 to 2014	158	188	158	145		

(Source: Danske Universiteter)

In 2007, overall composition of received research funds by the eight universities is as follows: 57% from public sources, 23% from private sources, 12% from EU programs, and 7% from others. In 2014, overall composition of received research funds by the eight universities is as follows: 55% by public grants, 26% come from private sources (including private Danish companies, as well as research foundations), 12% are from EU funding, and the remaining 7% from other sources. Thus, within the period of 2007 to 2014, funding from public sources has decreased by 2%, while funding from private sources has increased by 3%.

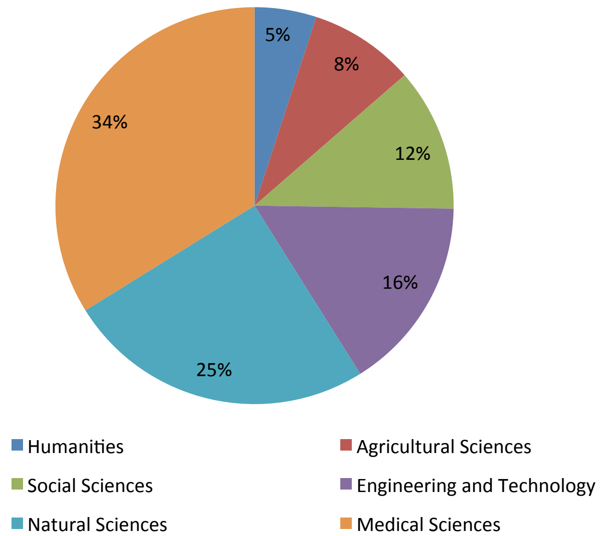
Considering the funding sources individually, data shows that private national grants exhibit the highest increase amounting to 188% from 2007 to 2014. Though, funding from private national sources only contributes with 26% of total university research funding.

As can be derived from Table 8, all universities experienced an increase in research funding between 2007 and 2014. The two Universities ITU and AAU show the highest increase where research funding more than doubled between the considered period of seven years, closely followed by the university of Copenhagen (KU).

4.1.4. Industry Funding of Different Scientific Disciplines

Regarding differences between R&D funding among scientific disciplines, the next figure shows how R&D investments are concentrated among the different scientific disciplines. As previous research literature suggests, the academic discipline is a key factor in determining collaboration activity with industry and thus, included in the analysis (D'Este & Patel, 2007; Bozeman & Gaughan, 2007).

Figure 3.: Danish Enterprises Funding of R&D Expenditures by Scientific Fields, 2014



(Source: Statistics Denmark, 2014)

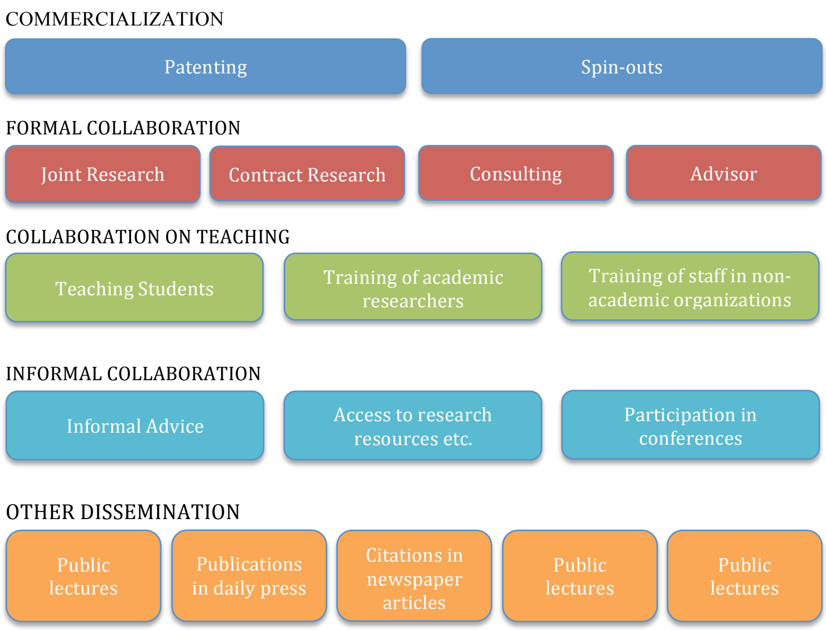
The data in Figure 3 shows that two scientific fields stand out in terms of R&D activities, and together received more than half of total R&D investments in 2014. Whereas medical sciences slightly take over the leadership, they are closely followed by natural sciences. Thereafter, engineering and technology related fields, and social sciences follow, while agricultural sciences and humanities form the lower end. This data indicates, which scientific fields are the most attractive ones for industry sectors and thus, probably also show more intensive and frequent collaboration with non-academic partners. This picture can be explained through the business profile of Denmark's economy, where the major part of the business sector is dominated by small and medium-sized enterprises (SMEs) mainly operating in low-tech sectors, the well-positioned agricultural sector, the fast-growing pharmaceutical industry, and the energy and public hospital sectors are essential collaboration partners for the universities (Gregersen & Rasmussen, 2011, p. 289; Lundvall, 2009).

4.1.5. The Main Collaboration Channels and Types of Research Agreements

To date, there is no exact figure of the amount and diversity of all collaboration agreements between universities and businesses in Denmark. While often the share of industry funding of university R&D is regarded as an indicator for UI collaboration intensity (Bozeman, Fay & Slade, 2012), this indicator does not provide any additional information on the diffusion and usage frequency of different collaboration channels.

In general, a large-scale survey among all full-time academic researchers at seven of the eight Danish universities (University of Southern Denmark did not participate) provided responses of 3.272 university researchers (accounting for a response rate of 26%) on *the extent of collaboration between researchers and non-academic* partners (DEA, 2014, p. 7), and also what collaboration mechanism they use. Out of all respondents, 75% stated that they have had some kind of engagement with non-academic researchers over the past three years. The data revealed that Danish researchers make use of a broad set of collaboration mechanisms, comprising both, informal and formal channels. The subsequent figure gives an overview of all collaboration mechanisms that Danish academics use to collaborate with non-academic partners.

Figure 4. Types of Collaboration Channels between Danish Academics and External Partners



(Source: DEA, 2014)

Another interesting finding in this study is how the engagement in collaboration activities with non-academic partners was distributed among scientific disciplines. As presented in figure 5, collaboration with non-academic partners was most spread among social science participants. This finding is somehow surprising as suggested by research literature collaboration being more popular among the technical oriented sciences (Lee, 1996). This is especially relevant in terms of the scope of the current thesis where respondents from the social sciences and the technical sciences are interviewed and thus, indicates that the social sciences are a relevant collaboration partner for industry.

Figure 5. Percentage of Respondents by Scientific Discipline

	Arts & Humanities	**Social Sciences**	**Health Sciences**	**Technical Sciences**	**Natural Sciences**	**Agricultural Sciences**	**Total**
Percentage with collaboration	79 %	86 %	66 %	82 %	61 %	83 %	75 %
No. of respondents	284	628	276	530	527	136	2.460

(Source: DEA, 2014)

For the interpretation it is important to note, that the survey included all "*non-academic collaborations*" and thus, did not exclusively consider collaboration mechanisms with private companies, but additionally those with public institutions. Therefore, the results are not representative for collaboration mechanisms exclusively used by Danish researchers and industry. Further, the response rate of 26% limits the representativeness of results for total population of Danish university researchers (DEA, 2014, p. 21). Nevertheless, the study is unique in its approach to measure the *extent of collaboration* and thus, findings reveal interesting insights and provide an idea of the extent and diversity of collaboration channels in use between Danish academic researchers and industry.

To sum up, Danish researchers seem to access a diversified set of collaboration mechanisms for their interaction with external partners. However, the majority of respondents has never or only to a small degree collaborated with external partners at all (DEA 2014).

Data on Collaborative Research Agreements

The next table provides an overview all privately funded research agreements of national sources, compare to all externally funded research agreements that were open in 2014 at each university. A more detailed overview can be found in Appendix F. Research agreements are considered at university-level, but are further distinguished among five scientific disciplines: the humanities, social sciences, health sciences, technical and engineering sciences, and other fields that are not part of the aforementioned.

Table 9. Open Grant-Based Research Projects per university and scientific discipline, 2014

	KU	AU	SDU	RUC	AAU	DTU	CBS	ITU
B. National Private Sources	**1.762**	**2.317**	**848**	**78**	**1.080**	**811**	**76**	**9**
Humanities	95	255	52	23	67	-	-	-
Social Sciences	78	161	66	27	86	-	-	-
Health Sciences	978	1.077	522	-	178	-	-	-
Technical or Natural Sciences	611	819	208	28	749	811	-	9
Others - Outside of main disciplines	0	5	-	-	-	-	76	-
TOTAL open Agreements	**4.447**	**5.493**	**1.864**	**441**	**3.248**	**3.642**	**254**	**56**

(Source: Danske Universiteter)

The data gives insights into the research project intensity of each Danish university, and also how collaboration is diverging between the different scientific disciplines. Thus, the universities of Arhus and Copenhagen executed the most research projects in 2014, closely followed by DTU and AAU. Derived from this, technical and natural sciences taking over the leading position embracing 58% of all open agreements on research projects. An interesting finding is that among the four different scientific areas considered in the data, social sciences reveal the lowest amount of research agreements even less than the humanities and the natural sciences. This is contrasting the findings presented in figure 5, and leads to the assumption that if social sciences show high collaboration activities with overall non-academic partners but lower with private companies, than they mostly engage in collaboration with other public organizations.

The next table gives an overview of different kinds of collaborative research agreements between the universities and other institutions that were newly signed within the years of 2013 and 2014. Basically, the table distinguishes three categories of collaborative research agreements. The first category includes those agreements that are exclusively between universities and private companies. Firm contribution can be in financial terms as direct funding, but also in-kind funding (Dansker Universiteter). Here, Danish but also international companies are considered. The second category is including mixed agreements between the university and public actors like research councils, foundations, programs, etc. but also private partners as co-funders or participants (ibid.). The last category includes research agreements that were solely between universities and public organizations. Additional information obtained through an employee working as a senior advisor at the organization "Universities Denmark" revealed some additional attributes of the term '*collaborative research agreements'*. Included in the term are all types of research and development cooperation, including clinical trials. Excluded are pure sponsorship, where no quid pro quo is expected, consultancies between individuals where the institution is not part of the agreement, agreements about student projects or internships, non-disclosure agreements, material transfer agreements and declaration on intent, and agreements about termination or extension.

Table 10. Overview of newly signed Collaborative Research Agreements in 2014

Collaborative Research Agreements	KU	AU	SDU	RUC	AAU	DTU	CBS	ITU	Total
With private companies	283	340	77	27	295	643	29	2	1696
With public research councils, foundations & public programs involving paticipation and co-financing private companies	82	75	34	19	103	215	28	9	565
With public organisations	182	17	80	68	379	41	31	5	803
Total	**547**	**432**	**191**	**114**	**777**	**899**	**88**	**16**	**3064**

(Source: Danske Universiteter)

Overall, the data indicates, that collaborative research agreements (CRAs) with private companies outweigh those with other external collaboration partners in the year 2014. On the university-level, the data shows that the universities differ significantly in their overall collaborative research patterns ranging from only 16 to 899 total newly signed CRA's in 2014.

DTU is by far the leader of newly signed CRA's, amounting to 899 bits in 2014, closely followed by the University of Aalborg (777), Copenhagen University (547) and Arhus University (432). The lower end is formed by Roskilde University, Copenhagen Business School and IT University. Thus, overall data in this section suggests the increasing relevance of private companies within the research activities of Danish universities.

Internal Organization and Supporting Structures

As already presented in the literary background in chapter 2, universities' internal transfer-oriented infrastructures are another important indicator to determine the propensity of UI collaboration (Renault 2006). The establishment of TTO's inside universities is one initiative to support academic researchers in their collaboration activities with industry (Friedman and Silberman 2003). Related to this, Friedman and Silberman (2003) suggest that an early established, thus now experienced technology transfer office within universities is a vital contributor in facilitating transfer activities between university and industry. In order to assess the technology transfer support-structures within Danish universities, Table 11 provides data on the number of employees working in technology transfer related functions at the eight institutions.

Table 11. Number of full-time equivalent employees in technology transfer at the end of 2014

	KU	AU	SDU	RUC	AAU	DTU	CBS	ITU
Number employees	14	20,5	11,3	0,25	11	19	1	0,8

(Source: Danske Universiteter)

Data reveals that all universities employ only a few equivalent to full-time employees for internal technology transfer organization. This indicates that at the institutional level, UI collaboration has not yet reached a level where this phenomenon is playing an important factor within decisions on internal organizational infrastructures at Danish universities. Among all, again KU, AU, DTU and AAU show the highest employments in terms of employees assigned with technology transfer organization activities. However, it has to be taken into consideration that the eight universities vary in their size, and overall amount of employees. Thus, the presented numbers of full-time employees should be interpreted relative to overall institutional workforce.

4.1.6. Summary – First Research Question

Answering the first RQ this prior section presented data on (1) Denmark's research and innovation system, (2) external funding structures of academic research, (3) a comparative analysis of the research profiles of the eight Danish universities based on collaboration activities with industry, and (4) concentration on different scientific disciplines. The most relevant insights are summarized into seven propositions:

- Proposition 1. *Denmark is a country with strong innovation and research performance facilitated by several political initiatives.*
- Proposition *2. The Danish industry sector is the main contributor in terms of R&D investments, but also the main performer of R&D.*
- Proposition *3. Despite higher industrial contributions to overall R&D investments, the share of industry funding for academic research remains lower compared to funding from public sources.*
- Proposition 4. *Industry funding of academic research projects is mainly concentrated on two scientific disciplines, namely medical sciences and natural sciences, which is in accordance with the predominant business sectors of pharmaceuticals and agricultural industrial sector.*
- Proposition 5a. *Danish academic researchers make use of a diversified set of collaboration channels, whereas informal ways of collaboration outweighs formal types of collaboration.*
- Propositions 5b. The *four Danish universities that show the strongest indicators for UI collaboration are KU, DTU, AAU and AU.*
- Proposition 6. *UI collaboration shows an upward trend in Denmark, but has not yet reached a level of institutionalization.*

4.2. Consequences of Industry Funding on Academic Core Activities

What has been presented so far provides a primarily quantitative outline of UI collaboration in Denmark. The tendency to measure the extent and value of collaborative activities through quantitative indicators often tends to leave other impacts unacknowledged (Bozeman et al., 2012). Thus, the following section is also one attempt to call for the appreciation that UI collaboration is a multifaceted and complex phenomenon that cannot be fully captured in numerical terms.

In order to investigate the potential impacts of industry-funded research on university researchers' core activities, qualitative data was derived from fourteen interviews and will be analyzed in the following. During the interviews, the participants were asked several open questions on how they experienced collaboration with industrial partners compared to publicly funded projects, how they think that industry-funded research projects have impacted their job-related functions at the university, and how they individually manage such relationships.

In order to derive answers to the second RQ, the analysis and presentation of key findings moves along the three related sub-questions: (1) *What are potential impacts on research and teaching activities?* (2) *Do academic researchers experience a conflicting situation between his/her individual convictions and industry expectations?* (3) *How do academic researchers personally manage such collaborative research projects with industry?* A summary of the structure of the following thematic analysis is provided in Table 12.

Table 12. Summary of structure of thematic analysis

Overall Theme	Category	Thematic Focus
1. Impacts on Researchers' Core University Activities	1. Research Activity 2. Teaching Activity 3. Fundraising Activity 4. Administration Activity	How industry-funding of research projects subsequently influences academic researchers' core functions at the university
2. Perception & Management of Situation	1. Conflict vs. No Conflict 2. Coping Strategies	Do academic researchers perceive industry-funding as conflicting or not conflicting with their core academic functions, how do they manage this situation, and what are central recommendations to solve potential dysfunctions

4.2.1. The Impact on Academic Researchers' Core Activities

In order to uncover the central functions that academic researchers have to fulfill during their daily work, an introductory question aimed to collect information on the respondents' background and current job-related activities at the university. The data revealed three main areas of responsibility and one supportive function translated into four categories for the subsequent analysis: research activity, teaching activity, fundraising activity, and administration.

So the three areas, so to say, is to educate in courses, to make research and publish, and to raise money to hire people, and also that is how we sustain the department, and funding is both, private and public funding (...). (Respondent #C)

Impacts on Research Activity

In order to present the impacts of industry funding on academic research activities, the thematic analysis uncovered three main areas of research that could be subsequently grouped into the categories: *research quality, research orientation* and *research productivity*, and will be presented in the following.

Research Quality

Research quality here refers to the integrity and trustworthiness of research activities, especially concerning the knowledge included in publications, and also the level of exposure through different actors on research results. Interviews reveal that industry funding has both positive and negative impacts on research quality. One positive effect of industry-funded projects regarding the quality of academic research, considers the possibility of receiving feedback afterwards. One researcher from the technical/engineering discipline highlights the value of receiving industrial feedback for the feasibility or practicability of the invented technology after the project has finished, for subsequent research activities in the following way:

So we get a much more interesting dialogue into what is the real world problem, and if we come to an implementation stage, we also get the feedback of how it actually works. So this is something we can get out of a collaboration project. (Respondent #C)

Another relevant factor that has positive influence on research quality is the access to enormous amounts of data from the inside of a firm. These rich datasets support the validity of research findings as it is mentioned by respondents during the interview.

So, yeah, the companies enable you to specialize. But most of all the companies enable you to, I don't know how much we should into that, but the real advantage and that is my book, that you get data that other people cannot get (...) if you work inside a company as an action researchers your get access to all data. (Respondent #J)

Another respondent from the economics/business administration disciplines support the point of validated data in the following way:

Because I think, many people don't have this time and energy and are allowed to be in the organization for so much, because I also attend social events and I talked to people in the cafeteria and all these relationships help me to get authentic data and they don't have to tell me what they think I want to listen to so they actually more authentic and more truthful. So in that sense whatever results I get its *actually, you know, it is actually validated because of this methodological choice compared to having, you know, a pure qualitative survey based scale from one to seven and all that funny stuff. (Respondent #H)*

On the other hand, respondents mention several negative impacts related to industry funding. At least one researcher from the scientific/engineering discipline describes negative experiences through company requests for '*selective publishing'* and the '*bypassing of critical information'* that can impact research quality.

When we are publishing the source that has been made with direct involvement from a company, then we are obliged to have whatever material we produce, like a graph, for a journal or conference, that will go through the company before we sent it out. So, they check if there is any sensitive information, and if there are controversy there, we discuss how to solve that. (…) but we also work on things sometimes that is so sensitive that we don't publish that particular part. (Respondent #C)

Further, several researchers from the technical/engineering disciplines explain that companies often require to receive the documents in advance of publication date, in order to check if reports include any sensible data. As this process can take a while, often this causes another publication delay. Consequently, the information that is revealed within delayed papers often appears to be already outdated when others get access to it.

A researcher from the economics/business administration discipline delineates a similar situation, and acknowledges that he modifies findings or at least, the interpretation of findings upon companies' requests. He explains this experience with the words that he '*sort of downplayed'* the data. This indicates that the data, when published, is presented in a distorted way in order to hide potential sensitive information that is of importance to the company.

For instance, there were in one of the projects, there were certain disclosure areas which we found was of limited interest to investors and analysts, and so forth, and I think that, well this is confidential, okay, and I think that ehm the company did not really like the results, but we agreed that we should report the results but then we also agreed that the specific interpretation of the results, like well the results have this and that implications, we sort of downplayed that (…). (Respondent #I)

Other statements indicate that companies often include specific terms in contractual agreements to secure "*confidential research*", "*first order right to access*", "*first right of diffusion*", "*partial restrictions*" and "*non-disclosure agreements*", which indicate that other companies can only access these datasets with certain delays.

Another factor that can have negative consequences on research publication, are industrial commercialization purposes. Put in the words of one researcher form the technical/engineering discipline:

There is also another complexity when we work for a company. If we make a discovery on something that could potentially enhance their process or they could do things in another way, then often they would like that we explore the opportunity to patent that invention, before we can publish. So, sometimes even if we have a strategy and one could put out the results early, we might have to go through a phase, where we have experts sitting down and evaluating if certain results have commercial value and if that should be pursued as a patent strategy before we can publish, and that can delay the process. (Respondent #C)

This statement points into the direction that companies often push university researchers to patent inventions that are the results of collaborative projects. As the process of patent application and finally receiving the patent grant takes a while, the information included in the patent description will be revealed when the patent is granted and is kept secret before.

Despite this withholding of relevant information required by industrial partners, one researcher from the technical/engineering disciplines goes further and says that such withholding requirements can also result into a complete blocking of certain research areas.

So, now, imagine you work now for instance in the area of development of proteins or something similar, and you make a collaboration with a company that develops proteins (…), and you assign the rights to your ideas in a project to a company, then this company could suddenly completely block a certain area of your research, where they can say you can not work here, or you can not publish here because you have signed something here. That means you have to be extremely careful, what you sign there and why you sign it. (Respondent #E)

Another fact that is mentioned by the researchers regards experiences with the diffusion of an '*anti-research mentality'* towards more basic/fundamental research among faculty members when research activities become too much dependent on the funding of one single company. Additionally, this can have counterproductive effects on academic researchers' creativity.

Yes, so a part of the institute in which I am now, was long time committed to one company in the development of fuel cells. This has led to a certain mentality that is hostile to research. So it was no longer that you really tried different new ways, but also to optimize, to 1% here or 1% there, or a different strategies comes to bear. If this happens over a too long period of time, yes I see this as harmful, because then one loses the creativity also as a researcher. Creativity is maintained when you have different challenges and whether these are research projects or different industrial co-operation, I think there is roughly the balance. (Respondent #F)

Research Relevance

Relevance in this regard refers to the degree to which academic researchers adjust their research activities in favor of industrial interests. In fact, respondents describe that their research agendas shift towards industrial relevant topics, after a collaborative research project with a company.

When we suggest new projects, we always check what industry is doing and what is important. In our case, especially the Danish industry or Scandinavian industry. (Respondent #B)

Other terms that are used within this context include research activities becoming more '*end-user focused*', '*consumer oriented'* or '*being more useful for society'*. Interestingly, this impact described only in positive terms by all academic researchers. They highlight that they always wanted their research becoming more relevant for society.

One researcher from the technical/engineering discipline emphasizes the opportunity to learn from the long-term experiences of industrial researchers on relevant problems during collaborative projects:

(…) but it also means that we get much more: we get availability for data from the company, we get long-term experiences by the engineers and the operators and the people sitting in the company and that tell us about the problems they see. (Respondent #C)

Another positive finding on research relevance is that collaboration positively influences the subsequent '*effectiveness of the research dissemination'*. During the interviews it becomes clear, that when the research project is in collaboration with an industrial partner, also the probability increases that research findings will reach a much more broader and diversified audience. In fact, research results are then communicated via traditional academic mechanisms such as publication and conferences, but additionally disseminated through industrial channels, and thus speak to a much more broader audience of managerial practitioners, authorities and policy-makers, compared to only reaching other academics. One researcher from the economics/business administration discipline frames it in the following way:

One of the advantages is that the dissemination of the research findings, the possibilities for that are much, much stronger in a collaboration. Because you have to remember when we have collected our data, when we have analyzed our data, then we also use the company resources to sort of expose our findings, to communicate our findings, (…) they organized I think it was four workshops only devoted to the results of our projects. And they, organized of course everything about the publication they organized that. And then later on, the project was presented to regulators (…) in the UK as well, so I just think that the possibilities for dissemination of research results are much stronger, when we do these collaborations. Because if we only do publicly funded projects, then our main publication would be an academic article sometime in the future, and you probably know that those people that read academic articles are other researchers only, perhaps students, but not practitioners or regulators. (Respondent #I)

Beside those more positive impacts, respondents also reflect on several negative aspects. One frequently mentioned issue in this context is the short-term orientation of industrial research projects, which can happen to the detriment of a long-term research perspective. This is often accompanied by a narrowed research scope, where only current issues are of interest to the companies, and fewer projects are undertaken to conduct research out of pure academic interest. Many of the researchers explain that collaborative projects with a company are often very specific and targeted on a single practical issue, and that industry interests and benefits move into the center of the collaboration.

I think it would be more interesting to have projects where we are free to investigate things that we think are interesting to do research in, than do were it is always oriented towards companies results all the time. (Respondent #A)

One researcher from the technical/engineering discipline states that when research follows money, one consequence is that researcher try to match their research direction with those areas where industry provides funding:

(...) because you go there where the money is, (...), you have to make sure, that at the end there is someone who is willing to pay for what you are doing research in. (...) And then you really think already in advance about what area you are doing research in. (Respondent #E)

This indicates that industry is able to indirectly control research efforts to the advantage of their own interests and can guide research in specific directions.

Research Productivity

Interview participants discuss the topic of research productivity in terms of research publications, as well as in terms of working on other research projects. Positive impacts on research productivity are most likely described in the way of subsequent spill-over effects.

(...) I think a lot of other industries can benefit from my work, from my approach, and also from findings from this particular research project. I haven't started on the process yet, but I am sure that other companies will be interested in having a collaboration with me again. (Respondent #H)

Another fact regards that prior collaborative experiences help to increase a mutual understanding between academia and industry, which supports academic researchers in subsequent collaboration processes:

It has also influence, if one understands the language of industry, one can of course also talk with other companies much more effective. (Respondent #F)

Further, higher financial turnovers can increase research productivity. As the researchers explain, privately funded collaboration is often based on higher overhead rates and thus, the additionally generated money can result in the employment of additional researchers for their department. In the words of one researcher from the technical/engineering discipline:

Funding gives more funding. One reason is that we show that we can perform well with one industry, then that makes other industries interested. (Respondent #D)

Additionally, researchers describe that industry-funded projects often result in inspiration and new ideas for future research projects.

(...) but of course it is the case that whatever fields you work with is influencing and inspiring, you will get new ideas. So, I am for example, I collaborated with the company XY that is one that whose main products so to speak, is based on treatment to skin, and since I know a lot about that then, whatever research ideas I get is also inspired by the work we do there (...). So in that sense it influences the generation of new ideas, and new research ideas. (Respondent #G)

Thus, researchers explain that in this way industry-funded research projects have also positive effects on their basic research in the way that they find new areas of research that are interesting for them and do not necessarily need collaborative projects with companies. One researcher from the technical/engineering disciplines says it in that manner:

(...) also often when you work with practical problems you find out that here is actually an area of basic research where there is also all kind of stuff that you could do. (Respondent #G)

On the other hand, among the respondents there is a general consensus that industry funded research projects are quiet time-intensive and require a high workload and that this can distract from other job-related activities. So, one research from the technical/engineering disciplines expresses it in the following way:

But every project, I mean, you only have a certain amount of hours for working, and each time there is a project, you can do less of something else. (...) So ehm, each time we do one thing, you cannot do other things, right? (Respondent #D)

The time-intensity of collaborative industry projects is also described in terms of having less time for research publications, as said in the words of one researcher:

It takes all my time! It takes all my time, and that is why I don't have time to produce to publicist. (Respondent #K)

Another fact that is described by the respondents regards that often firms make restrictions regarding simultaneous or subsequent collaboration projects with other firms, especially with direct competitors. This could negatively impact the overall research productivity in terms of conducting other research projects simultaneously or discuss potential future research projects with other firms.

Impacts on Teaching Activity

Impacts on teaching activities are experienced in a more indirect way as highlighted by the majority of respondents, and are primarily perceived as positive. The identified impacts of industry funding on teaching activities, are presented based on three main categories: *teaching quality, teaching orientation and teaching productivity*.

Teaching Quality

Teaching quality here refers to the quality of course content and is explained through students' evaluation feedback, and through their participation behavior. The respondents explain that they increase teaching quality for their students by creating course contents accordingly to industrial interests as apparently, students' interests go hand-in-hand with those of industry.

There is a very close relation, in what companies like, and what students like. (Respondent #D)

In fact, all respondents have the experience in common that their students appreciate it very much if professors integrate either industrial content through own prior research experiences or through the direct involvement of industrial partners during lectures. One researcher from the economics/business administration disciplines expresses this in the following way:

(...) so you use those cases all the time to demonstrate the conceptual theoretical model, so what you are teaching. And that is an interesting thing I used up, those who love that most are actually the students (...) the students, I got some tested feedback, that they think it is interesting that they have a professor who can all the time give practical examples of what he is saying. So the students really love that I must say. (Respondent #J)

Further, one respondent describes a situation where the course attendance of students is dependent on the level of involvement of a certain company:

(…) *So for example, we had a course, where we had many students, because it was related to the thing we were doing with the company I mentioned before, so people were very eager to because of the possibility to work in this company, or in this area of technology. Then the company decided to step down a little bit, they are still doing it but less, and then the students heard that, and then they did not come for the courses anymore. (Respondent #J)*

Others receive positive feedback through student course evaluations, where professors receive higher scores when industrial inputs are incorporated into course agendas:

(…) *And I always get top performance ratings in my teaching. (Respondent #N)*

Through the contributions of the respondents it really seems that students' interests are closely aligned with those of industry, and thus, the inclusion of industrial actors into course creation becomes obligatory.

Teaching Relevance

Teaching relevance refers to how teaching orientation shifts after collaborative projects. In fact, teaching agendas are affected by several means through researchers collaborative activities with industry. First, several participants mention that after the finalization of an industry-funded research project, they start to revise current course curricula inspired by research areas of the collaborative projects. Participants also state that a subsequent integration of new topics into the study syllabus, especially those of industrial relevance, is not uncommon but mostly only to a small degree.

It is more of an indirect impact I would say, how it can be thematically integrated, in what is already taught. This can maybe be small nuances where we say okay this might be a more relevant detail instead of this, what I have experienced from the company side that can be an interesting issue. But it is not that the overall theories will be changed that are used during the lectures. (Respondent #F)

Second, most researchers from both disciplines support the idea that the integration of real-based case examples are important in order to prepare the students for their future placements in industry, and thus, industrial relevance is considered when creating course content.

(...) but working with companies has a good impact on teaching, because we can provide sort of realistic examples, from the real world in the teaching, and in fact, we in fact experience that the students prefer courses where there is some possibility to use it in the companies. (Respondent #D)

The respondents agree that it is never the case that industrial input replaces essential theoretical content, but that practical knowledge gained during projects can complement the theories learned from papers or textbooks.

(...) So, I try to make it as real as possible for my students that it is not abstract. And I think that creates good dynamic in the classroom, for sure. At least, I get that kind of feedback from my students. They think, they feel closer to reality that you know, than if it was another textbook that they are studying. (Respondent #H)

Respondents explain that they use practical knowledge from industry projects to remain updated on current trends and events in industry, as theories in textbooks were created on past events:

So it is much more about contextualization, it is much more about nuancing, and much more about knowing the updates, because theories are created in the past, while, when we are teaching, we should prepare you guys for the future, so that definitely needs a lot of updating. (Respondent #K)

Teaching Development

Teaching development refers to cases where respondents describe that collaboration has directly influenced the formation, creation or execution of courses. This includes for instance cases, were a study program could not have been offered to students without collaboration of a company. Others refer to specific study programs or courses that are directly based on industrial collaboration or industry input. One professor from the economics/business administration discipline provides one example of a Master program that is jointly created with industrial partners:

Yeah, well, the accounting firms provide the teachers for that. (...) So I think that if you take total teaching of the program then I guess that around, probably around 80% or something of the time, when the teaching is done by external teachers. (Respondent #I)

Another professor explains that the design of one course structure incorporates the final development of a real innovation that will be transferred to certain company afterwards or is already transferred during the course. This example a fortiori supports the importance of considering companies during courses and course creations, but overall, impact on teaching development remains scarce.

Impacts on Fundraising Activity

All respondents confirm that prior acquisition of industry funding positively influences subsequent access to extra financial sources. There is a close relationship between funding activities and research activities, especially in terms of *research productivity*. Hence, the generation of additional funding sources also implies that increased financial resources become available and can be used to conduct further research.

Funding Access

The majority of the respondents explain that the participation in industry-funded projects increases their access to subsequent funding through a process they describe as a continuous iterative cycle. This process is mainly based on positive reputational spill-over effects based on positive feedback and recommendation by industrial partners afterwards, additional references on the CV, increased name recognition and eventually, the obtainment of an "*trusted advisor status*".

Very positive, because we experience that when people come to our department and ask for the project which they will fund, then they come because they have either read our papers or they have come because good reputation records from other projects. Funding gives more funding. One reason that we show we can perform well with one industry, then that makes other industries interested. Success also attracts other parties, both industry and research. (Respondent #D)

On the other hand, it becomes evident that certain spillover effect can be grounded in context-specificities:

If we made a project with the industry which was successful, I mean Denmark is a small country, everybody knows everybody, so if you get good reputation, and reputation (...) is the most important part of our business, (...) then we get much more requests for this type of research from others. (Respondent #B)

The researchers from the economical/business administrative fields are somehow more cautious when they talk about the impacts of receiving funding from industry on their further funding activities. This might be traced back to the fact that most of the respondents from the social sciences have only had one or to a limited set of industrial funded research projects. So, they can only talk about their assumptions and not about actual experiences.

I am not sure, there is no guarantee, right. And the problem with the private funding is, you never know. It is unstable, because, you know, business is unstable, right? If everybody is going down in a new financial crisis, nobody gonna fund research for sure. (Respondent #K)

Funding Composition

Next to impacts on funding access, industry funding can impact from which sources academic researcher receive funding in the future, if there is a growing the share of public or private funding in overall funding structures. The respondents agree, that industry funding positively influences the subsequent acquisition of both kinds of funding, public and private.

You write it on your CV that you had a project with this company and of course that can affect subsequent funding also, both public and private. But it could also have an effect on subsequent funding from the same company, of course if they want to continue along the same lines on a new project. (Respondent #A)

Besides this, several respondents highlight that industry funding can especially have an impact on attracting public funding. This is because for many publicly funded research projects it is also necessary to include industrial collaborators, and then when you already know each other, the collaboration gets easier. One researcher from the technical/engineering discipline makes a statement that is also representative for the other participants:

Well, it is quiet clear now, and I think we will continue in the future, that the access to private fund means that we can boost our public fund. (...) We would be simply not able to raise public money, we did not have the private also. (Respondent #C)

Impacts on Administration

Administration activities are job-related activities that cannot be directly attributed to one of the three core activities of teaching, research or fundraising, but rather are regarded as fulfilling a supportive function. Several researchers mention that it is sometimes difficult to distinguish between administration that can be traced back to research activities, and administrative efforts that are caused through teaching activities. They describe that administration is often in-between several activities:

For example, how do you count administration? You go into the project, which means that you have reporting, you have accounting, you have administration of PhD students or whatever…. Is it teaching or research? You don't know. (Respondent #B)

Nevertheless, the interviews reveal that industry-funded projects induce extra workload for the academic researchers, most often caused through intensive initial negotiation phases. One respondent from the technical/engineering discipline says:

The initial negotiation phases are then often longer than actual project duration. So it is not uncommon, that you discuss more than one year, and the subsequent project is about a timeframe of 6 or 9 month (…). (Respondent #F)

Other arguments indicate that initial organization and coordination phases are connected to the highest administrative burdens. This includes sourcing and screening activities for future projects through the writing of applications and proposals. One researcher from the technical/engineering disciplines frames it in the following way:

Ehm, we do spent a lot of time in organizing and writing proposals and finding like the management of getting projects, so even before the research starts. That is significant activity, and that is not really counted anywhere. (Respondent #C)

With regards to industry-funded research project, researchers from both disciplines agree that administrative work is most often caused through different legal foundations of universities as public institutions, and companies as private institutions.

But then after you made such a preliminary agreement, he walks to the lawyers of the DTU. And then we spend at least half a year communicating between each other and between the lawyers who try to find a common basis for the rules of the public institution and the internal rules of the company, and background knowledge and rules of financing (…) And finally we get 50 pages document consisting of paragraphs with full of the lawyer language, which we have to read and to sign in order to make our job, with which we agreed in 5 minutes. (Respondent #B)

One respondent from the economics/business administration disciplines uses the following words to describe the differences between public and private bureaucracy:

We have enormous resistance from the administration to deal in a diligent way with companies. They are just causing problems here. I mean, the administration, those the projects I mentioned, our sponsors let us use their finances much freer than CBS administration, so time after time we get comments from CBS administration that you cannot do that without support, you cannot do that without support, and the sponsors are so fed up with this, that they say "you can dot it!". That's so, now you cannot because the administration here does not allow it. (Respondent #J)

4.2.2. Conflict Potential & Management Strategies

After the previous presentation of the impacts that industry funding has on university researchers job-related activities, this section proceeds with a presentation of how university researchers individually perceive these impacts and how they proceed to manage the collaboration. It is evaluated if academic researchers describe industrial and university expectations as conflicting or non-conflicting, and then how they individually manage UI collaboration effectively.

Conflict vs. No Conflict

The majority of respondents regard collaboration with industrial partners as very valuable and important for their academic conduct. All respondents highlight positive experiences with industry-funded research projects, and even if potential conflicts occurred, these can be solved quickly on an individual basis. Respondents describe collaboration with industry as '*Give-and-Take'* relationships or as a *'win-win situation'*, which is facilitated through a certain level of trust and mutual understanding between the two parties.

And the industry I mean, when I talk to the engineers from industry, we can find a common language in 5 minutes. Okay, let us do this, we need this, this and that. We need such and such type of experience, and ok, this we can do, this we cannot do, this costs that much. So that is all we need. And then normally, we know each other, so it's our usual contract, so we trust each other. (Respondent #B)

This feeling is especially expressed when researchers are asked to compare industry funded projects with those funded by other non-academic partners. One researcher from the technical/engineering discipline explains:

(...) for example if I compare it with an EU project then, I remember one time we were told (...), some people came to like hear the results, and there were not enough results, and then we were told okay, they can switch off the funding if they are not satisfied with us, or something like that. But I never heard that in connection with a private company, and it might be because they are not ehm, they are accepting the difficulty to the research and not really ehm, they are not that strict in the same sense you could say, they are happy if some results are coming but they are not threatening to cut of the funding in the middle for example. (Respondent #A)

Additionally, respondents describe that their interests most often are in accordance with those of industrial partners. Researchers describe that they want their research to be useful for society, that they "*want to be dependent*" on industry, and that companies are their mechanism to transform research findings into tangible outputs that can enhance society standards.

I mean we work well together because we want the same thing, we want our results to be used. That we are not in different worlds, we are in the same. So for us, my department at least, it is not so *difficult. (…) we are fed up being not so independent, but rather we want our research to come into play. (Respondent #D)*

Overall, university researchers from both scientific disciplines are not concerned that industry funding could interfere with their conduct of traditional academic activities. One researcher explains:

The interests of the industry are most often on a different sequence and a different level, compared to what we are doing here as research. (Respondent #F)

While no negative aspects are mentioned, a few respondents express that they experience some factors at least as challenging during collaborations. For instance, the feeling to satisfy multiple expectations simultaneously, the different time-dimension that characterizes the business world, where "*Business works for time and academy works for future.*" Others describe that industry-funded research projects often require a balancing act between "*competitive value for companies and research value for the researchers*".

Some respondents mention that conflicts can also be related to a lack of trust within the partnership, and that conflicts are more likely to appear with new collaboration partners. Thu, it is highly important to sustain good relations with key persons in the company.

Additionally, respondents' arguments indicate that the emergence of negative influences is not an exclusive problem to industry funding. Respondents explain that similar problems can also appear during projects funded by other non-academic institutions. One researcher from the technical/engineering discipline brings it to the point:

I think the more you have strict targets on where you can apply for research fund, that is always a threat for being able to conduct exploratory and independent research. But that is also the case for public funding. Because, the government is setting targets for which area would they like to have research conducted. So even for public funding certain areas become almost impossible to raise money and therefore, it is not going to be pursued. (Respondent #C)

Management of Situation

The question remains *why the majority of academic researchers do not see themselves exposed to a conflicting situation*, *although the data shows that there are in fact potential negative impacts.* The answer to this is emerging from the interview data and reveals that university researchers develop diverse strategies as an immediate response to manage collaborations effectively. These strategies have a preventative function and come into effect well in advance of the actual project. Thus, successful collaboration becomes a matter of "*personal management*" as one respondent explains. The two major strategic concepts of '*balancing*' and '*pre-selecting'* emerge from the data. Both strategies contain a diversified set of strategic options for the academic researchers. The following Table 13 provides an overview of identified strategies and provides essential examples:

Table 13. Overview of Preventative Strategies – Balancing & Selection Strategies

Strategy		**Example:**
I. Balancing Strategies:	**1. Balance the Collaboration Portfolio**	"*Through diversity you can prevent of getting a one-sided point of view on reality." (Respondent #F)*
	2. Balance the Funding Portfolio	Including public and private funded projects in research portfolio: "*When I am looking to the areas of research I would like to pursue or work in a future of some years, there are some topic areas where I see this is necessary that it will be done entirely on public fund, and there are others where I see this is something we could do very interestingly in collaboration with a company. So I select a little bit of what I put in the proposal." (Respondent #C)*
	3. Balance Industrial & Public Interests	"*And then we set a research plan, where there are results of general interests for the general public, but there is also specific development that helps their engineering department and servicing their customers. (...) it is designed in a way, so they have very direct influence about what type of tasks are we going to look at and how we are going to develop. And then it is my job, to identify what is the general research outcomes, while we are solving this specific problems with the company. (Respondent #C)*
II. Selection Strategies:	**1. Purposeful Topic Selection**	**1. Avoid projects that require to bring in your research core competencies:** "*(...) that are partly also tactical considerations that you have to make yourself, so if you know that someone else has the right to keep everything that you produce for himself, and that you potentially remain empty-handed, than I would eventually say, okay now I am only contributing with knowledge that is not part of my core-competences. " (Respondent #E)*
		2. Only collaborate on certain topics with industry: "*(..) we know on beforehand that there are topics that if we start doing research about them in collaboration with the industry, then in the end, when we get our results then here could be a delicate situation. So, from the outset we are just saying, well, we cannot collaborate on that topic because we don't want to end up in that situation where we have to sort of discuss whether or not these results should be published." (Respondent #I)*

4.2.3. Summary – Second Research Question

Overall, results show multiple impacts on the three core activities research, teaching and fundraising of academic researchers. Whereas impacts on research activity appear to be negative and positive, impacts on teaching and fundraising are only described in positive terms. All of the three identified core activities seem to be accompanied by an increase in administrative workload triggered through industry-funded research projects. The main impacts are summarized in Table 14.

Table 14. Overview – Impacts of Industry Funding on Research, Teaching, Fundraising Activities

Categories	**1. Research**	**2. Teaching**	**3. Fundraising**
Sub-Category	Quality	Quality	Access
Impacts: (+ / -)	+ Industrial feedback + Substantial data access + Data validity - Withholding of data - Selective publishing - Modification of data interpretation - Publication restrictions - Diffusion of anti-research mentality - Decreasing creativity - Blocking of research areas	+ Increased attendance of students + Great evaluation/ feedback from students + Satisfaction + Alignment of students and industrial interests	+ Increased access + Reputational effects + References for CV + Recommendations + Spillover effects
Sub-Category	Orientation	Orientation	Composition
Impacts: (+ / -)	+ Application-oriented + End-user focus + Useful for society + Real-world problems + Extended research dissemination + Reaching a broader audience - Narrowed scope of research topics - Less long-term & fundamental research	+ Modification of teaching agendas + Real-world cases + Industrial relevance + Complementary Knowledge + Other involvement of industrial partners	+ Acquisitions of further private funding + Acquisition of future public funding
Sub-Category	Productivity	Development	
Impacts: (+ / -)	+ Spill-over effects + Mutual understanding + Financial turnover + Inspiration & generation of new research ideas - Time-intensity - Extra workload - Restriction to collaborate with competitors - Cancellation of projects - Granting of patents	+ Course Creation + Co-created Study programs + Transfer of Student's Inventions to Industry	

- Proposition 7a. *There are negative and positive impacts on research activities, while there are only positive impacts on teaching and fundraising activity.*
- Proposition 7b. *Positive aspects of industrial contribution dominate potential negative trade-offs, and industrial input is beneficial and complementary to academic core job-related activities.*

The second part of the qualitative analysis reveals some interesting findings on how university researchers manage collaboration projects with industry in such a way that they become an integral part of their daily work-related activities. In fact, they develop a set of preventative strategies that become effective well in advance before the actual collaboration project starts. The two main strategies identified here are *Balancing Strategies* and *Selection Strategies,* which help academic researchers to accomplish multiple expectations at the same time.

- Proposition 8. *The majority of academic researchers do not perceive a conflict between industrial and academic interests, as they want their research to useful for society.*
- Proposition 9. *University researchers develop individual preventative strategies apart from university supportive infrastructures, in order to manage industrial collaboration successfully and to circumvent conflicting situations.*

Following from this, it is suggested that both worlds can co-exist within the academic environment and that impacts of industry-funded research projects rather have a leveraging effect on university researchers' core functions, than that they interfere with them.

4.3. Summary

This chapter has presented the results of the analysis that form the grounding for answering to the two guiding research questions. First, key findings on the current state of affairs of UI collaboration in Denmark were presented. By first outlining the national policy framework for UI collaboration in Denmark, analysis reveals that UI collaboration has merged into a central focus of national policy-makers. This process is facilitated by several governmental initiatives and supporting programs aiming to further strengthen collaborative relationships between industry and academia. In fact, several policy initiatives are presented that were developed in order to stimulate the level of R&D investments within the public and private sector. In terms of industry funding for academic research, industry investments remain relatively low, where Danish enterprises only contribute with around 2,5% to total funding received by Danish universities. However, there is an up-ward trend of industry funding for academic research considering the period of 2007 to 2014. Additionally, the amount of newly signed research agreements between the universities and private companies increased between 2013 and 2014. All together, while UI collaboration indicators suggest an upward trend expecting further collaboration to grow in the future, findings suggest that UI collaboration is has not reached institutionalized standards and the country has not yet exploited collaboration opportunities to their fullest potential.

Second, the chapter continued to outline the results on potential impacts of industry-funded academic research on the core activities of university researchers. Summarizing the results, it is suggested that industry funding comes with its advantages and disadvantages for other job-related activities, whereas positive impacts are stronger pronounced. Despite the existence of positive and negative impacts, academic researchers do not seem to perceive industry-funding or industry collaboration in general as conflicting with their academic core activities. Rather they describe those experiences with industry as complementary to their academic research activities as industrial input is positively contributing to research and teaching conduct. The absence of major conflict potential caused through collaboration with industry, is explained through the finding that respondents have developed a set of preventative strategies, and accordingly make use of certain strategic techniques to design collaborative relationships with companies in such a way that conflict potential is minimized.

5. Discussion

This chapter relates essential empirical findings of the current study, to existing findings in research literature outlined in chapter two. This will help to shed light on theoretical contributions of the current study. Additionally, findings are discussed in connection to their contextual grounding Denmark, in order to derive some practical implications for policy-makers and universities.

5.1. Consequences of Industry Funding & Conflict Management

A comprehensive body of research has already elaborated on potential consequences resulting from university researchers' increased collaboration with industry. The more pessimistic view is concerned that these additional activities interfere with the accomplishment of traditional job-related activities, such as research and teaching (Ankrah et al., 2008; Geuna, 2001). A central argument within this discussion is that academic researchers could feel themselves exposed to conflicting demands from academia and industry (Ankrah et al., 2008). Whereas academic research complies with the fundamental principles of open science, industrial interests could interfere by expecting to obtain exclusive access to research findings in exchange of research funding (Pisano, 2010).

A contrary perspective in literature is that through the integration of industrial objectives into the academic world, core university activities are reinforced and simultaneously managed through an entrepreneurial oriented mind-set (Perkmann et al. 2013). University researchers could excel themselves by simultaneously managing teaching, research and collaboration activities within inter-disciplinary academic settings (Gibbons et al., 1994).

The empirical findings of the current study broadly fall into the latter perspective, while suggesting a complementary relationship between academic researchers' core activities and their simultaneous engagement in industrial projects (proposition 7b.). Despite the widespread concerns expressed in literature concerning academic researchers being exposed to conflicts of interest when simultaneously trying to fulfill the expectations from academia and industry (Ankrah et al., 2008), the findings of the current study point into a different direction. As a matter of fact, findings indicate minimal conflict potential between academia and industry (proposition 8.). Findings indicate that academic and business interests go hand in hand and are further facilitated through mutual understanding and trust. Concerns are only experienced when collaboration partners are new and relationships lack trust. The predominantly positive attitudes of academic researchers toward collaboration are somehow unexpected regarding the amount of prior research findings indicating major conflict potential. One possible interpretation is that the majority of interviewed researchers has multiple experiences with industry and thus, they show in general less skepticism towards such collaborative research, as otherwise they would not have agreed to enter such projects again, or at least, they are '*less willing to admit negative consequences'* (Guldbrandsen & Smeby, 2005, p. 942). This is also supported by literature on individual characteristics where '*prior experiences'* are a determining factor for intensification of further collaboration. As also provided in the literature background, matching and/or mismatching of expectations and achieved benefits afterwards will determine further collaboration activities (Ankrah et al., 2013). Another consideration is that scientists come from two scientific fields where collaboration might be more accepted among the academic community compared to other areas and thus, show less skepticism.

In fact, the most essential finding emerging from the data is that academic researchers develop individual strategies that allow them to manage industrial collaboration effectively. This proves that academics' are well informed about potential areas of conflict either based on own prior experiences or through their colleagues' experiences. Preventative strategies composed of a set of tactical considerations, characterize the personal management of university researchers as emerging from the data (proposition 9.). These strategies are not only used to manage ongoing collaborative research projects, but rather come into effect well in advance of the actual collaboration. While research literature suggests that the challenge to find the right way to manage collaboration effectively is on the pat of the universities (Blumenthal et al., 1986, p. 1361), the current study suggests that when institutional support is not immediately available, then this is compensated through individual strategies of academic researchers. Slaughter et al. (2002) suggest similar findings stating that academics' would have developed their own ways to cope with the conflict of interest *"between patenting and publishing"* (p. 302). They describe two strategies developed by professors: first, making the right choice about timing of publications what they call "*sequencing*"; and second, adjusting information and data included in publications framed as "*sanitizing".* Accordingly, both tactics can help to prevent conflicts of interest or at least, reduce them. Once again, the significance of the individual is highlighted as being the central decision-maker in such collaboration, whereas institutional factors are not necessarily decisive, suggesting that if a university lacks proficient supporting infrastructures, academic researchers have found ways to compensate insufficient institutional conditions. In the present study, findings reveal that academic researchers make use of at least two different preventative strategies: *balancing strategies* and *selection strategies*. Both strategies include different tactics created to cope with UI collaboration in the best way, attempting to retain benefits and reduce risks to a minimum.

To sum up, findings indicate that researchers are attentive and thoughtful towards potential impacts of industry funding. They seem to be well aware of potential positive and negative effects on their academic activities and strategies to accommodate traditional values with newer roles and to satisfy multiple expectations simultaneously. Overall, and opposed to general concerns that industry-funded academic research could distract academic researchers from more fundamental and basic research objectives, findings refute this by suggesting that industry funding even stimulates basic research projects.

5.2. Interpretation of Findings in the Danish Context

All findings of the current study need to be linked to their contextual grounding. Country-specific and institutional (university) conditions need to be considered in order to interpret findings correctly and also to derive relevant implications for Danish practitioners. The analysis in chapter 4 revealed that Denmark's economic system implies favorable prerequisites for UI collaboration in terms of Denmark's strong innovation and research performance (proposition #1). The significance of UI collaboration to retain a leading position on an international level has already moved into a central focus within national politics. In fact, the government has started several initiatives and support programs that aim to further strengthen the collaboration between academia and industry. Despite governmental responsiveness, the institutional environment of Danish universities is lagging behind. This becomes obvious during the interviews when the academic researchers express their feeling that the university has not the right supporting infrastructures in place: *I don't know, what office is that? What office is coordinating what? I wonder… (…) So there is an office that coordinates funding? I think there is a central function that tries to get a general support from donators, but that is probably a slightly different thing. I mean, they provide no support to any of this, as far as I know.*

Further, this is prevalent in the statistical data in Table 11**,** showing that only a few employees at the universities are directly responsible for technology transfer activities. Thus, it seems obvious, that the academic researchers develop their own management strategies to cope with UI collaboration.

Therefore, the identified preventative strategies might be a customized solution for the Danish context, when Danish universities do not offer enough support structures assisting academic researchers in their organization and problematic areas of UI collaboration. Therefore, it is likely that when collaboration is in another context then academic researchers face different problems, might have better support from university side, or collaborate in a different regulatory and legal system. For instance, in Denmark there is a law that attributes intellectual property rights to the employing institution, not to the employed inventor himself (Baldini 2006). In this case, when an academic researcher invents something and the university evaluates this invention as valuable to grant a patent, then the IPR remains with the university. The same legislation is in place in several other EU countries (ibid.), but considering the fact that there regulations in other countries differ, this also influences the collaboration between university and industry. Especially, there are different needs to align academic incentive systems for university researchers to participate in industry-funded research, because they will probably publish less, and at the same time, will not even retain the ownership of their inventions.

5.3. Contributions and Implications

Based on the discussion above, the findings of the current study induce some theoretical and practical implications, which will be presented in the following section.

Theoretical Contributions

As outlined in the introductory chapter, this thesis aims to contribute to the research literature on the phenomenon of UI collaboration in general, and in particular, contribute to the literature investigating the impacts of industry funding on core academic functions. The current thesis contributes with at least five theoretical contributions:

1. Consideration of academic research projects that are exclusively funded by industry
2. Validation of existing findings on potential consequences of industry funding on academic research activities
3. Extending research findings on the impacts of industry funding on teaching activities
4. Support for the argument that UI collaboration depends on individual level characteristics
5. The combination of different academic areas as a contextual grounding for UI collaboration
6. Approach to measure UI collaboration

As outlined within the literature background, research literature uses various notions in order to describe the phenomenon of UI collaboration, which can be misleading. Often the broader term *collaboration* includes entrepreneurial and commercialization activities as well as various other types of informal and formal interaction activities between university and industry. So far, the impacts of collaboration on academic researchers' core functions have been primarily studied with regards to entrepreneurial and commercialization activities, whereas less studies set their focus on collaborative research projects exclusively funded by industry. Thus, this study contributes with relevant findings to research literature that exclusively considers industry-funded research projects.

Second, this study validates existing findings in research literature by providing empirical evidence on the impacts of industry funding on academic core activities and connecting them to prior literature. Especially, empirical findings extend existing research literature on impacts on teaching activity, whereas findings provide relevant and new insights that need further investigation.

Further, this study methodologically contributes through including respondents from the well-studied areas of technical/engineering science with respondents from the less-studied area of social sciences. This integration is one attempt to encourage future research on the phenomenon of UI collaboration to extend empirical focus to other scientific areas. It is necessary to note, that the objective of the current study was not to follow a comparative research approach, where two distinct scientific areas were systematically juxtaposed. Rather, the rationale behind choosing two distinct scientific fields was based the aim to make findings more robust and representative for the average. Nevertheless, a comparative study could be a relevant step, in order to identify areas of similarities and differences, and to support a better understanding of the dynamics in social sciences.

Finally, this study contributes to common methodological approaches measuring UI collaboration in terms of patenting, licensing and spin-off activities, or through publishing and citation rates (Bozeman et al. 2013), by including record data on contractual agreements between the universities and industry, counts of newly-signed collaborative research agreements held by universities, and numbers of employees responsible for technology transfer activities at each university. This approach aims to capture collaboration modes that remain undetected if measures are limited to commercialization activities, and is one attempt to sensitize further research to agree on a standardized measurement for UI collaboration activity.

Practical Implications

Despite the theoretical contributions, this study also provides some practical implications to universities, policy-makers and companies. First and foremost, implications are relevant to the Danish audience, but also inform practitioners from other geographical contexts on important areas to consider when organizing UI collaboration.

The discussion of results confirms that Denmark is still on its way to institutionalize UI collaboration and make it part of the daily business of university and company management, which should be further strengthened within policy effort as according to academic researchers such collaborations clearly benefit their other academic core functions. Several strategic initiatives show that all relevant stakeholders in Denmark work on support structures to strengthen these collaborations. Nevertheless, based on the contributions of informants there are still some inconsistencies and space for effective UI collaboration management.

To Universities: Implications for universities center around two main topics: (1) university incentive systems and (2) institutional infrastructures. First, incentive systems based on performance indicators must be aligned with objectives of UI collaboration. Often universities tend to exclusively incentivizing publications and patenting activities, disregarding the additional value and positive impacts of collaboration activities. Thus, in order to support UI collaboration, universities need to reconsider their incentive systems. An important step in this context concerns that universities need to track UI collaboration activity, and need to create databases collecting all relevant data on different types of UI collaboration and their distribution. This is an important step into the direction of acknowledging also collaborations that cannot be traced back through the use of common indicators such as publications, citations, patenting and licensing or spin-off activities.

Second, it becomes obvious that at least in Denmark, institutional infrastructures to support academic researchers in their efforts to collaborate with industry are not well in place. Thus, universities need to establish central offices that serve as a point of contact for academics who participate in industry collaboration. Especially, countries were not yet supporting structures are in place inside universities it is important to think about solutions that can assist the academic researchers in reducing their administrative burdens that come with increasing research projects. If academic researchers have no support then there is the risk that time devoted to administration reduces time devoted on research and teaching activities.

To Policy-Makers: First, it appears that too much a focus on formalization standards for collaboration agreements is detrimental to effective execution of UI collaboration. Academic researchers claim for liberalization of legislation and regulation, and for more agreements based on trustful relationships. Additionally, policy-makers have to incentivize industry in the right way to promote UI collaboration among industry sectors, i.e. through taxation rules or other benefits for companies.

Second, it is important that policy-makers acknowledge the diversity of collaboration channels. In many cases, activities related to the commercialization of academic research through patenting or licensing are the major concern in policy debates. Consequently, the significance and existence of other collaboration channels remains unappreciated. Here, it is especially necessary, that policy-makers are informed about the availability, advantages, disadvantages, requirements, and conditions encompassing different types of interaction channels. Eventually, different channels need to be supported by different regulatory frameworks and supporting programmes.

Third, based on the composition of the Danish industrial ecosystem, it appears that industry funding of academic research is mainly divided between two scientific disciplines. Here, it is important that policy-makers set up initiatives and programmes that specifically support UI collaboration within the more disadvantaged scientific areas.

Finally, insights call for increased transparency, for instance through the implementation of the obligation to attach the source of funding to publications and other documents presenting research findings, in order to reveal any potential bias that could exist between the researchers objectivity and independence in conducting research and the interpretation of research results.

To Companies: Also companies need to establish internal infrastructures that are in favor of collaboration with academia. Companies should appoint responsible officers, in charge of managing and organizing all collaboration related aspects with academia.

Second, companies should be able to evaluate the success of a collaboration project. This could be done through the implementation of techniques to measure the degree of research results that were. This can help to measure the usefulness of research projects for companies and also help university researchers to receive feedback and to assess what knowledge was of specific relevance and practical usability.

6. Conclusion

Within the realm of universities as stimulators for technological development and innovativeness, their interrelationships with industry have gained increased attention by researchers from multiple scientific areas. Although not a new phenomenon, the occurrence of UI collaboration for effective knowledge transfer has drastically increased during last decades (Meyer-Krahmer & Schmoch, 1998; Perkmann et al., 2013) companied by policy frameworks supporting collaboration between university and industry. In this regard, complementary streams of theory study the phenomenon of UI relationships and have become a central topic within research of sociology of science today (Meyer-Krahmer & Schmoch, 1998; Perkmann et al., 2013). Investigations range from the new entrepreneurial role of universities, the variety and frequency of knowledge transfer mechanisms, individual motivations to engage in collaboration, to research conducted on the intensity of collaboration among different scientific disciplines and industrial sectors (Meyer-Krahmer & Schmoch, 1998). But overall, opinions remain controversial towards how far universities' active role in technology transfer and research commercialization should reach, as constituting a potential threat to the traditional academic fun of research and teaching activity.

The present study addresses this research gap, by investigating first the current state of affairs of UI collaboration in Denmark and then, exploring potential impacts of industry funding on the performance of academic researchers core activities. In order to process the first research objective, statistical data from multiple sources was collected and subsequently analyzed in order to outline the current state of affairs and future outlook on UI collaboration in Denmark. Afterwards, fourteen interviews were conducted with academic researchers from two Danish universities in order to analyze their collaboration experiences with industry-funded research projects, to elaborate subsequent impacts on research and teaching activities, and find out about what management strategies they use for successful collaboration.

The analysis of the statistical data on Denmark reveals that the country is still on a developing path to institutionalize UI collaboration. Several governmental programs were implemented to foster the collaboration between universities and industry, but UI collaboration has not yet reached a status of institutionalization at Danish universities, where industry funding still accounts for only a minor share of total research funding.

The analysis of interview data reveals that UI collaboration has several negative and positive consequences for academic research, teaching and fundraising activities. Among others, significant findings suggest that collaboration can stimulate teaching and further research activities through access to inspiration and generation of new ideas. Both, research and teaching become more application-oriented and thus, universities can fulfill the expectation to contribute to national economic growth and social welfare. Besides the fact that there are positive and negative influences on academic core activities resulting from industry funding, positive impacts gain increased awareness among university researchers and seem to outweigh the negative ones. In fact, findings indicate that academic researchers develop individual strategies and rely on a specific set of techniques to manage collaboration with industrial partners effectively, and to cope with potential conflicts of interest between the academic and business world. Findings suggest that they make at least use of two strategies, namely "*Balancing*" and "*Selection*" strategies.

As a consequence, UI collaboration does not seem to happen to the detriment of a commitment to traditional university values and functions. Rather university researchers perceive industrial input as very welcoming and complementary to their job-related functions of teaching and research. In case the institutional infrastructures for assisting academic researchers in their organization with industry are not well in place, they have autonomously developed preventative strategies to manage collaborations successfully.

6.1. Limitations

This study is subject to at least four limitations. First, one limitation is based in the empirical scope of the study. This study is limited to the Danish context, which means findings are exposed to country-specific factors and conditions and therefore, limits the generalizability and applicability to other geographical contexts. Denmark is, with its approximately 5.6 Mio. inhabitants (OECD, 2016), a rather small country and might thus presents different economical and social conditions compared to other larger (EU) countries. The results are subject to context-specific factors such as its higher education and innovation system, or societal and economical developments and therefore, restrict the transferability of research findings to other geographical contexts. Especially, with regards to higher education systems, severe discrepancies can arouse considering differences in regulations on intellectual property rights and promotion systems of employed researchers and professor.

Second, the selected sample is limited in size and scope. The sample comprises a rather small sample of fourteen researchers who affiliated to two Danish universities. In fact, Denmark's higher education system is composed of eight universities and thus, the underlying sample cannot claim to be representative for all universities in Denmark. Further, while the focus is set on Danish universities, not all respondents had the same national affiliation. Thus, the sample might not be representative for Danish academics in general, as cultural differences might interfere.

Third, the scope of the study is limited to the academic environment, referring to perceptions of one group of actors only, namely the academic researchers. Additional valuable insights could be gained through including other stakeholder groups in the data collection. Here, considering an additional perspective towards UI collaboration through interviews with involved students could help to clarify impacts on teaching.

Next, based on its qualitative design, the reported findings are based on self-reported data and thus, exposed to several interpretation biases (Saunders et al., 2009). It could be challenging to replicate the current study and derive at the same findings for other researchers. This is mainly caused through the underlying research approach of semi-structured in-depth interviewing. Here, the process of an interview is always influenced by situational factors and the interplay of individuals involved. Thus, although the same questions will be used in an interview, the outcome can vary based on an interference of individual interpretations and personal biases. For instance, it is possible that participants purposefully withhold information during interviews, as it is either confidential or because they feel uncomfortable sharing it.

Fifth, the research scope is limited to collaborative projects with industry, more specifically those solely funded by industry. This leads to the exclusion of valuable insights into research projects with other non-academic partners and projects that are in collaboration with industry but not exclusively financed by the private sector.

Lastly, the research design does not allow the distinction between academic researchers from the technical/engineering disciplines, and those contributing within the area of social sciences. This limits the potential of the current study to disclose a broader variety of insights regarding differences among the two scientific disciplines. Overall, the findings of the present thesis contribute to research on a more general level and stimulate future research in the field of social sciences.

6.2. Avenues for Future Research

The present study opens up some avenues for further research. First of all, the comparatively low amount of existing research papers studying how industry funding impacts the educational function of professors and directly influences teaching activities and training of graduates, implies a need for further research in this area. The so far restricted research in this field might be caused by the fact that in fact there is less impact compared to those on research activities. On the other hand, some impacts could remain unrecognized due to the methodological difficulty to measure impacts on the *quality* of teaching. Thus, further research in this direction could be beneficial. One suggestion here is to include more student perspectives though for instance using the evaluation forms submitted by students at the end of a course, in order to investigate how the professors that are engaged in industry-funded research projects, perform within their teaching function based on students' assessment.

Second, it is important to extend the one-sided perspective followed in this study to a multi-dimensional perspective, considering besides the university professors, also academic staff in charge of managing collaboration at the institutional level. This is extremely relevant, in order compare impacts of industry funding in of terms diverging institutional supporting infrastructures. As data suggests, some universities are in fact ahead of others regarding internal organizational support and employed personnel for technology transfer activities, and university management should be informed on how institutional support systems can be efficiently designed to best serve UI collaboration.

Next, most studies regarding UI collaboration and academic entrepreneurship focus on a limited set of scientific disciplines. This study was one attempt to bridge the gap between the well-studied and less-studied scientific disciplines, by including respondents from the technical/engineering sciences and those from the social sciences. In order to understand how collaboration can be best supported, managed and organized within each scientific field, research focus should be extended to areas like social sciences and humanities. This is likely to lead to better a better understanding of needs and requirements, which would help supporting the strategy implementation for those areas.

Fourth, other studies should extend research on collaborative research projects to those with non-academic partners and other external funding sources, not only focus on industry. Here, it could be interesting to compare the differences and similarities of influences between privately and publicly funded projects, and mixed projects. This became especially relevant during the interviews indicating that academic researchers experiences with publicly funded and privately funded research projects are in many aspects similar.

Clearly speaking, there is still a lot of potential for further research to address the aforementioned inconsistencies. The presented findings should be seen as a point of departure for further research within this area. Especially, research on impacts on teaching and fundraising activities should be developed further as this study delivers first ideas and concepts that need additional empirical grounding and validity.

7. References

A

Ankrah, S.N., Burgess, T.F., Grimshaw, P., and Shaw, N.E. (2013). Asking both university and industry actors about their engagement in knowledge transfer: What single-group studies of motives omit. *Technovation.* 33(2013), 50-65.

Arrow, K. (1962). Economic welfare and the allocation of resources for invention. In: Nelson, R (ed.), *The rate and Direction of Inventive Activities.* Princeton Univ. Press, Princeton, 609-625

Aschhoff, B., and Grimpe, C. (2014). Contemporaneous peer effects, career age and the industry involvement of academics in biotechnology. *Research Policy*. 43(2014), 367-381.

Azagra-Caro, J.M. (2007). What type of faculty member interacts with what type of firm? Some reasons for the delocalization of university-industry interaction. *Technovation.* 27(2007), 704-715

Azagra-Caro, J.M., Archontakis, F., Gutiérrez-Gracia, A., and Fernández-de-Lucio, I. (2006). Faculty support for the objectives of university-industry relations versus degree of R&D cooperation: The importance of regional absorptive capacity. *Research Policy.* 35(2006), 37-55

B

Baldini, N. (2006). The Act of inventions at public research institutions: Danish universities' patenting activity. *Scientometrics.* 69(2), 387-407.

Beaudry, C., and Allaoui, S. (2012). Impact of public and private research funding on scientific production: The case of nanotechnology. *Research Policy.* 41(2012), 1589-1606.

Bekkers, R., and Bodas Freitas, I.M. (2008). Analyzing knowledge transfer channels between universities and industry: To what degree do sectors also matter? *Research Policy.* 37(2008), 1837-1853

Blumenthal, D., Glucks, M., Louis, K.S., Stoto, M.A., and Wise, D. (1986). University-industry research relationships in biotechnology: implications for the university. *Science.* 232(4756), 1361-1366.

Blumenthal, D., Campbell, E.G., Causino, N., and Louis, K.S. (1996a). Participation of Life-Science Faculty in Research Relationships with Industry, *The New England Journal of Medicine,* 335(23), 1734-1739.

Blumenthal, D., Causino, N., Campbell, E., and Louis, K.S. (1996b). Relationships between Academic Institutions and Industry in the Life Sciences – An Industry Survey, *The New England Journal of Medicine,* 334(6), 368-373.

Boardman, P.C. (2008). Beyond the stars: The impact of affiliation with university biotechnology centers on the industrial involvement of university scientists, *Technovation,* 28(2008), 291-297.

Boardman, P.C., and Ponomariov, B.L. (2009). University researchers working with private companies. *Technovation.* 29(2009), 142-153

Boote, D. N., and Beile, P. (2005). Scholars before researchers: On the centrality of the dissertation literature review in research preparation. *Educational Researcher,* 34(4), 3-15.

Boyce, C, and Neale, P. (2006). Conducting in-depth interviews: A guide for designing and conducting in-depth interviews for evaluation input. Watertown, MA: *Pathfinder International Tool Series, Monitoring and Evaluation-2.*

Bozeman, B., and Boardman, C. (2013). Academic Faculty in University Research Centers: Neither Capitalism's Slaves nor Teaching Fugitives. *The Journal of Higher Education.* 84(1), 88-120.

Bozeman, B., Fay, D., and Slade, C.P. (2012). Research collaboration in universities and academic entrepreneurship: the state-of-the-art, *Journal of Technology Transfer,* 38(1), 1-67.

Bozeman, B., and Gaughan, M. (2007). Impact of grants and contracts on academic researchers' interactions with industry, *Research Policy,* 36(2007), 694-707

Brooks, H. (1994). The relationship between science and technology. *Research Policy,* 23(5), 477-486.

Brooks, J. and King, N. (2012). Qualitative psychology in the real world: The utility of template analysis. In: *2012 British Psychological Society Annual Conference*, 18th-20th April 2012. London, UK. (Unpublished). Doi: http://eprints.hud.ac.uk/13656/

Brooks, J. and King, N. (2014). Doing Template Analysis: Evaluating an End of Life Care Service. *Sage Research Methods Case.* Doi: http://eprints.hud.ac.uk/19707/

Broström, A. (2012). Firms' rationales for interaction with research universities and the principles for public co-funding, *Journal of Technology Transfer.* 37(2012), 313-329.

Bruneel, J., D'Este, P., and Salter, A. (2010). Investigating the factors that diminish the barriers to university-industry collaboration. *Research Policy.* 39(2010), 858-868.

C

Caraca, J., Lundvall, B., and Mendonca, S. (2008). The changing role of science in the innovation process: From Queen to Cinderella? *Technology Forecasting & Social Change,* 2008.

CBS (2016) Facts and Figures 2016, doi: http://www.cbs.dk/files/cbs.dk/call_to_action/cbs_factsfigures_2016_web.pdf, last accessed 10th of December 2016.

Cohen, L., Manion, L., and Morrison, K. (2007). Research Methods in Education. *Routledge,* London, 6th edition.

Cohen, W.M., Nelson, R.R., and Walsh, J.P. (2002). Links and Impacts: The Influence of Public Research on Industrial R&D. *Management Sciene,* 48(1), 1-23.

Crespo, M., and Dridi, H. (2007). Intensification of university-industry relationships and its impact on academic research. *Higher Education.* 54(2007), 61-84.

Czarnitzki, D., Grimpe, C., and Pellens, M. (2015). Access to research inputs: open science versus the entrepreneurial university. *Journal of Technology Transfer.* 40(2015), 1050-1063.

Czarnitzki, D., Grimpe, C., and Toole, A.A. (2014). Delay and secrecy: does industry sponsorship jeopardize disclosure of academic research? *Industrial and Corporate Change,* 1-29. Doi: 10.1093/icc/dtu011

D

Daniels, J., and Brooker, J. (2014). Student identity development in higher education: implications for graduate attributes and work-readiness, *Education Research,* 56(1), 65-76.

Danish Government (2016). Denmark's National Reform Programme 2016. Retrieved from: http://ec.europa.eu/europe2020/pdf/csr2016/nrp2016_denmark_en.pdf

Dasgupta, P., and David, D.M. (1994). Toward a new economics of science, *Research Policy 23,* 487-521.

DASTI (2014). *Research and Innovation Indicators 2014. Research and Innovation: Analysis and Evaluation 5/2014*. Danish Agency for Science, Technology and Innovation: Copenhagen.

D'Este P., and Patel, P. (2007). University-industry linkages in the UK: What are the factors underlying the variety of interactions with industry? *Research Policy,* 36(2007), 1295-1313

D'Este, P., and Iammarino, S. (2010). The spatial profile of university-business research partnerships. *Papers in Regional Science.* 89(2), 335-350.

D'Este, P., and Perkmann, M. (2011). Why do Academics Engage with Industry? The Entrepreneurial University and Individual Motivations. *Journal of Technology Transfer,* 36(3), 318-339.

Dooris, M.J. (1989). Organizational adaptation and the commercialization of research universities, *Planning for Higher Education,* 17(3), 21-31.

Drori, G.S., Meyer, J.W., and Hwang, H. (2006). Globalization and Organization, World Society and Change, *Oxford University Press*

E

Erikson, T., Knockaert, M., and Der Foo, M. (2015): Enterprising scientists: The shaping role of norms, experience and scientific productivity. *Technological Forecasting & Social Change,* 99(2015), 211-221

Etzkowitz, H., Webster, A., Gebhardt, C., and Terra, B.R.C. (2000). The future of the university and the university of the future: evolution of ivory tower to entrepreneurial paradigm. *Research Policy,* 20(2000), 313-330.

F

Friedman, J., and Silberman, J. (2003). University Technology Transfer: Do Incentives, Management, and Location Matter? *Journal of Technology Transfer,* 28(2003), 17-30.

G

Gál, Z., and Ptacek, P. (2011). The Role of Mid-Range Universities in Knowledge Transfer in Non-Metropolitan Regions in Central Eastern Europe. *European Planning Studies*, 19(9), 1669-1690

Galambos, Louis (1987). The New American State: Bureaucracies and Policies since World War II. *John Hopkins University Press: Baltimore.*

Geuna, A. (2001). The changing rationale for European university research funding: are there negative unintended consequences? *Journal of Economic Issues.* 35(3), 607-632.

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., and Trow, M. (1994). The New Production of Knowledge – The Dynamics of Science and research in Contemporary Societies. *SAGE Publication,* London: Thousand Oaks.

Gray, D. E. (2014). Doing Research in the Real World. *SAGE Publications Ltd.* 3rd Edition, 756 pages.

Gregersen, B., and Rasmussen, J.G. (2011). Developing Universities: The Evolving Role of Academic Institutions in Denmark, in Göransson, B. and Brudenius, C. (Eds.) *Universities in Transition. The changing role and challenges for academic institutions.* New York: Springer, 283-305

Grimpe, C., and Fier, H. (2010). Informal university technology transfer: a comparison between the United States and Germany. *Journal of Technology Transfer,* 35(2010), 637-650.

Grimpe, C., and Hussinger, K. (2013). Formal and Informal Knowledge and Technology Transfer from Academia to Industry: Complementarity Effects and Innovation Performanc. *Industry and Innovation.* 20(8), 683-700.

Guba, E.G. (1981). Criteria for Assessing the Trustworthiness of Naturalistic Inquiries. *ECTJ,* 29(2), 75-91.

Guba, E.G. and, Lincoln, Y.S. (1994). Competing paradigms in qualitative research. In N.K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research,* 105-117. Thousand Oaks, CA: Sage.

Guldbrandsen, M., and Sembey, J.-C. (2005). Industry funding and university professors' research performance, *Research Policy,* 34(2005), 932-950.

H

Hagedorn, J. (1993). Understanding the rationale of strategic technology partnering: Interorganizational modes of cooperation and sectoral differences. *Strategic Management Journal,* 14(1993), 371-385.

Hall, B.H., Link, A.N., and Scott, J.T. (2001). Barriers Inhibiting Industry from Partnering with Universities: Evidence from the Advanced Technology Program, *Journal of Technology Transfer,* 26(2001), 87-98.

Hanel, P., and St-Pierre, M. (2006). Industry-University Collaboration by Canadian Manufacturing Firms, *Journal of Technology Transfer,* 31(2006), 485-499.

Haeussler, C., and Colyvas, J.A. (2011). Breaking the Ivory Tower: Academic Entrepreneurship in the Life Sciences in UK and Germany. *Reseach Policy,* 40(2011), 41-54.

Hottenrott, H., and Thorwarth, S. (2011). Industry Funding of University Research and Scientific Productivity, *Kyklos,* 64(4), 534-555.

Hycner, R.H. (1985). Some Guidelines for the Phenomenological Analysis of Interview Data, *Human Studies,* 8(1985), 279-303.

K

Katz, J.S. (1994). Geographical Proximity and Scientific Collaboration, *Scientomerics,* 31(1), 31-43

Kim, J., Lee, S.J., and Marschke, G. (2005). The Influence of university Research on Industrial Innovation. *NBER Working Paper Series.* Working Paper 11447

King, N., and Horrocks, C. (2010). Interviews in Qualitative Research. London: Sage.

Klevorick, A.K., Levin, R., Nelson, R.R., and Winter, S. (1995). On the sources and significance of inter-industry difference in technological opportunities. *Research Policy.* 24(2), 195-205.

Klofsten, M., and Jones-Evans, D. (2000). Comparing Academic Entrepreneurship in Europe – The Case of Sweden and Ireland. *Small Business Economics.* 14(2000), 299-309.

L

Laursen, K., and Salter, A. (2004). Searching high and low: what types of firms use universities as a source of innovation? *Research Policy,* 33(2004), 1201-1215.

Lavie, D., and Drori, I. (2012). Collaborating for Knowledge Creation and Application: The Case of Nanotechnology Research Programs, *Organization Science, 23(3), 704-724*

Lee, Y.S. (1996). Technology Transfer and the Research University: A Search for the Boundaries of university-industry collaboration, *Research Policy,* 25(1996), 843-863

Lee, Y.S. (1998). University-industry Collaboration on Technology Transfer: Views form the Ivory Tower, *Policy Studies Journal,* 26(1), 69-84

Lee, Y.S. (2000). The Sustainability of University-Industry Research Collaboration: An Empirical Assessment, *Journal of Technology Transfer,* 25(11), 111-133

Link, A.N., Siegel, D. S., and Bozeman, B. (2007). An empirical analysis of the propensity of academics to engage in informal university technology transfer. *Industrial and Corporate Change,* 16(4), 641-655.

Lissoni, F., Llerena, P., McKelvey, M., and Sanditov, B. (2008). Academic patenting in Europe: new evidence from the KEINS database. *Research Evaluation,* 17(2), June 2008.

Louis, K.S., Jones, L.M., Anderson, M.S., Blumenthal, D., and Campbell, E.G. (2001). Entrepreneurship, Secrecy, and Productivity: A Comparison of Clinical and Non-Clinical Life Sciences Faculty. *Journal of Technology Transfer.* 26(2001), 233-245.

Lundvall, B.A. (2009). The Danish model and the globalizing learning economy: Lessons for developing countries. *Working paper, UNU-WIDER Research Paper, World Institute for Development Economic Research,* No. 2009/18.

M

Mansfield, E. (1991). Academic research and industrial innovation. *Research Policy,* 20(1991), 1-12.

Mansfield, E., and Lee, J.Y. (1996). The modern university: contributor to industrial innovation and recipient of industrial R&D support, *Research Policy,* 25(1996), 1047-1058.

Martin, B., Salter, A., Hicks, D., Pavitt, K., Senker, J. Sharp, M., and Von Tunzelmann, N. (1996). The Relationship Between Publicly Funded Basic Research ad Economic Performance: A SPRU Review. *HM Treasury,* London.

McKeown-Moak, M.P. (1998). Book Review – Academic Capitalism: Politics, Policies, and the Entrepreneurial University by Sheila Slaughter and Larry L. Leslie. *Journal of Education Finance,* 24(Summer 1998), 135-140.

Meyer-Krahmer, F., and Schmoch, U. (1998). Science-based technologies: university-industry interactions in four fields. *Research Policy,* 27, 677-687.

Mora-Valentin, E.M., Montoro-Sanchez, A., and Guerras-Martin, L.A. (2004). Determining factors in thee success of R&D cooperative agreements between firms and research organizations, *Research Policy,* 33(2004), 17-40.

Moustakas, C. (1994). Phenomenological research methods. Thousand Oaks, CA:Sage.

N

Norris, P., Herxheimer, A., Lexchin, J., and Mansfield, P. (2005). Drug promotion. What we know, what we have yet to learn. Reviews of materials in the WHO/HAI database on drug promotion. *EDM Research Series No. 32, World Health Organization.* Retrieved from:
http://apps.who.int/medicinedocs/en/d/Js8109e/

O

OECD (2016): Gross domestic spending on R&D (indicator). Doi: 10.1787/d8b068b4-en
(Accessed on 28th of August 2016)

OECD (2016), Population (indicator). Doi: 10.1787/d434f82b-en (Accessed on 08th of December 2016)

Olmos-Penuela, J., Benneworth, P., and E. Castro-Martínez (2015): What Stimulates Researchers to Make Their Research Usable? Towards an ‘Openness’ Approach, *Minerva,* 53(2015), 381-410

Onwuegbuzie, A.J., Leech, N.L., and Collins, K.M.T. (2010). Innovative Data Collection Strategies in Qualitative Research, *The Qualitative Report,* 15(3), 696-726.

P

Patton, M.Q. (1990). Qualitative evaluation and research methods. *Beverly Hills, CA: Sage Publications, 2nd Edition,* 536 pages.

Perkmann, M. and Walsh, K. (2007). University Industry Relationships and open Innovation: Towards a Research Agenda. *International Journal of Management Reviews,* 9(4), 259-280.

Perkmann, M., and Salter, A. (2012): How to Create Productive Partnerships With universities, *MIT Sloan Management Review,* 53(4), 79-88.

Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Broström, A., D'Este, P., Fini, R., Geuna, A., Grimaldi, R., Hughes, A., Krabel, S., Kitson, M., Llerena, P., Lissoni, F., Salter, A., and Sobrero, M. (2013). Academic engagement and commercialization: A review of the literature on university-industry relations. *Research Policy.* 42(2013), 423-442.

Pertuzé, J.A., Calder, E.S., Greitzer, E.M., and Lucas, W.A. (2010). Best Practices for Industry-University Collaboraion. *MIT Sloan Management Review.* 51(4), 83-90.

Pisano, G. (2010). The evolution of science-based business: innovating how we innovate. *Industrial and Corporate Change,* 19(2), 465-482.

R

Rasmussen, E., Moen, O., and Guldbrandsen, M. (2006). Initiatives to promote commercialization of university knowledge, *Technovation,* 26(2006), 518-533.

Renault, C.S. (2006). Academic Capitalism and University Incentives for Faculty Entrepreneuship, *Journal of Technology Transfer,* 31(2006), 227-239.

S

Salter, A. J., and Martin, B. R. (2001). The economic benefits of publicly funded basic research: a critical review. *Research Policy,* 30(3), 509-532.

Saunders, M., Lewis, P., and Thornhill, A. (2009): Research Methods for Business Students. 5th edition, Pearson Education Limited, Essex, England.

Schartinger, D., Schibany, A., and Gassler, H. (2001). Interactive Relations Between Universities and Firms: Empirical Evidence for Austria, *Journal of Technology Transfer,* 26(2001), 255-268.

Schartinger, D., Rammer, C., Fischer, M.M., and Fröhlich, J. (2002). Knowledge interactions between universities and industry in Austria: sectoral patterns and determinants, *Research Policy,* 31(2002), 303-328.

Schutt, R.K. (2012). Investigating the Social World - The Process and Practice of Research. *SAGE Publications.*

Siegel, D.S., Waldman, D.A., Atwater, L.E:, and Link, A.N. (2003). Commercial knowledge transfers from universities to firms: improving the effectiveness of university-industry collaboration. *Journal of High Technology Management Research,* 14(1), 111-133.

Slaughter, S., Campbell, T., Holleman, M., and Morgan, E. (2002). The “Traffic” in Graduate Students: Graduate Students as Tokens of Exchange between Academe and Industry, *Science, Technology, & Human Values,* 27(2), 283-312.

Soh, P.-H., and Subramanian, A.M. (2013). When do firms benefit from university-industry R&D collaborations? The implications of firm R&D focus on scientific research and technological recombination, *Journal of Business Venturing (2013)*. http://dx.doi.org/10.1016/j.jbusvent.2013.11.001.

Strauss, A.L. (1987). Qualitative analysis for social scientists. Cambridge: Cambridge University Press.

Strehl, F., Reisinger, S., and Kalatschan, M. (2007). Funding Systems and their Effecs on Higher Education Systems, *OECD Education Working Papers,* No. 6, OECD Publishing.

Stuart, T.E., and Ding, W.W. (2006). When Do Scientists Become Entrepreneurs? The Social Structural Antecedents of Commercial Activity in the Academic Life Science. *American Journal of Sociology,* 112(1), 97-144.

T

Tartari, V., and Breschi, S. (2012). Set Them Free: Scientists' Evaluations of the Benefits and Costs of University-Industry Research Collaboration, *Industrial and Corporate Change,* 21(5), 1117-1147.

Tartari, V., and Salter, A. (2015). The engagement gap: Exploring gender differences in University-Industry collaboration activities, *Research Policy,* 44(2015), 1176-1191.

Thursby, J., and Thursby, M. (2003). University licensing and the Bayh-Dole Act, *Science,* 301, 1052.

Toole, A.A., and Czarnitzki, D. (2010). Commercializing Science: Is There a University "Brain Drain" from Academic Entrepreneurship? *Management Science,* 56(9), 1599-1614.

Turk-Bicakci, L., and Brint, S. (2005). University-industry collaboration: Patterns of growth for low- and middle-level performers. *Higher Education,* 49(2005), 61-89.

Tymon, A. (2013). The student perspective on employability. *Studies on Higher Education,* 38(6), 841-856.

W

Wright, M., Clarysse, B., Lockett, A., and M. Knockaert (2008): Mid-range universities' linkages with industry: Knowledge types and the role of intermediaries, *Research Policy,* 8(2008), 1205-1223.

Z

Zucker, L.G., Darby, M.R., and J. Armstrong (1998): Geographically Localized Knowledge: Spillovers or Markets? *Economic Inquiry,* 36(January 1998), 65-86.

7.1. Websites

Aalborg University:	www.aau.dk
Aarhus University:	www.au.dk
Copenhagen Business School:	www.cbs.dk
Danske Universiteter (Univesities Denmark):	www.dkuni.dk
IT University of Copenhagen:	www.itu.dk
Roskilde University:	www.ruc.dk
University of Copenhagen:	www.ku.dk
University of Southern Denmark:	www.sdu.dk
Technical University of Denmark:	www.dtu.dk

8. Appendix

Appendix A. Interview Guide

1. Could you please give a brief introduction about your person and your job-related activities at DTU?
   - (Include:
   - Responsibilities regarding research field
   - Main scientific discipline
   - Activities regarding education/teaching at university
   - Activities regarding research projects; scope and scale)
   - How many research projects were externally funded, which external financial source (diversity of experiences)

   → Following question should be answered in relation to most recent privately funded project:

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2. Could you please explain in detail how a publicly funded research projects is organized and coordinated? (From initial initiative to end)

3. Could you also please remember a specific privately sponsored project, and describe the process of this specific project?

   - Communication between involved actors/financing institution/company and researcher?
   - Besides providing the financial resources, what additional roles would you say, did the company/industrial actor take over? Control or influence of sponsor?

4. If you now compare those two projects, could you indicate concrete and/or immediate examples, that highlight a difference between privately and publicly sponsored projects?

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5. How did industry sponsorship influence your other/further research activities?
   - i.e. simultaneous projects?
   - i.e. follow-up research projects?

6. At the end of the project and with regards to your final research results, how were research findings treated, what happened to research outcomes, with regards to how they were made publicly accessible?

   → Who decided on the further treatment of the research results?

7. How did industry sponsorship influence your teaching activities?
   - i.e. with regards to course content and syllabus outline?
   - i.e. with regards to structures of lectures?

8. How did industry-funding affect subsequent industry funding or funding received from other sources?

9. Regarding the framework for University-Industry Collaboration, such as specific regulations and legislations, what do you think could be potential improvements or implementations in order to strengthen U-I interaction and to solve potential dysfunctions?

10. Do you see an increase in private sponsorship as a threat to research activities remaining open and independent?

11. What could be possible measures in order to establish a future balance between the potential influential power of specific industrial players through their financial sponsorship, and research remaining open and independent?

Appendix B. Interview Outline

Section	Questions	Rationale/Objectives
Introduction	1. Could you please give a brief introduction about your person and your job-related activities at your university?	• Become more familiar with individual backgrounds and diversity and variety of past experiences
Section 1 – Nature of Projects	1. Please, explain in detail how a publicly funded research projects is organized and coordinated? (From initial initiative to end) 2. Please, explain in detail how a privately funded research projects is organized and coordinated? (From initial initiative to end) 3. From your experiences, could you indicate concrete and/or immediate examples that highlight differences between those two types of projects?	• Detect and delimit the researchers' explicit understanding and definition of public and private research; recognize whether researcher participate more in collaboration regarding with public funding or private funded research projects
Section 2 – Impacts on Research	1. How does industry sponsorship influence your other and further research activities? 2. What happened to research results during and after the project? 3. Do you perceive an increase in private sponsorship as a threat of research activities remaining open and independent?	• Elaborating if researcher experienced any consequences for conducting further research activities; • Elaborating if choices made with regards to research agendas change; • Elaborating to what extent research has the right /is free to use research findings in a specific way • Elaborate on individual attitudes towards 'openness' in science or 'open science standards'

Section 3 – Impacts on Teaching	1. Can industry sponsorship influence your teaching activities, and if yes, how did that happened?	• Review if specific industrial sectors can shape what is part of education at an university
Section 4 – Impacts on Subsequent Funding	1. Has industry funding any impact on subsequent access to research funding?	• Examine if industry funding can potentially ease or impede with the acquisition of subsequent funding; • If industry funding can influence the future funding structure/ composition of a researcher
Section 5 – Policy Recommendations	1. Regarding the framework for U-I Collaborations, i.e. specific regulations and legislations, what do you think could be potential improvements and/or implementations in order to strengthen U-I interaction and to solve potential dysfunctions? 2. Do you see an increase in private sponsorship as a threat to research activities remaining open and independent?	• Investigate what advices individuals in question have for policy makers and practitioners; • Give researchers the chance to participate with suggestions for improvements; • Investigate whether they have any practicable and realizable suggestions in mind and if they think critically on UI collaboration

Appendix C. Initial Coding Template

1. RESAERCH ACTIVITIES

1.1. Research Productivity
  1.1.1. Delay
  1.1.2. Decreasing Productivity in terms of Publication
1.2. Research Agendas
  1.2.1. Agenda Setting (Lee 1996 & Blumenthal et al. 1986)
  1.2.2. Research direction
  1.2.2.1. Applied Research → “Neither commercialization nor engagement seems to skew academics’ research towards more applied topics.“
1.3. Treatment of Research Interaction,
  1.3.1. Secrecy
  1.3.2. Lower communication patterns
1.4. Behavior toward Research Community
  1.4.1. Communication Frequency/Patterns
    1.4.1.1 Less/Increasing Communication
    1.4.1.2. Higher Secrecy

2. TEACHING ACTIVITIES

2.1. Interaction with Students
2.2. Teaching Agenda
  2.2.1. Course Structure
    2.2.1.1. More Practical Relevance
    2.2.1.2. Case-based learning
  2.2.2. Course Content
      2.2.2.1. Current Issues and Topics from Real-world

3. FUNDING STRUCURE

3.1. Access to funding sources
  3.1.1. Access to Public Funding
    3.1.1.1. Increased Public Funding
  3.1.2. Access to private Funding
    3.1.2.1. Increased Private Funding

→ Relationship to TOPIC I: 1.1. Research Productivity – more projects

4. INDIVIDUAL PERCEPTION of COLLABORATION

4.1. Conflicting Situation
4.2. Non-Conflicting Situation

Appendix D. **Interview Transcripts on USB – Respondent Identification**

Initials	**Affiliated University**	**Date**
#A	DTU	26.04.2016
#B	DTU	27.04.2016
#C	DTU	29.04.2016
#D	DTU	29.04.2016
#E	DTU	02.05.2016
#F	DTU	03.05.2016
#G	DTU	04.05.2016
#H	CBS	19.05.2016
#I	CBS	19.05.2016
#J	CBS	31.05.2016
#K	CBS	03.06.2016
#L	CBS	03.06.2016
#M	CBS	03.06.2016
#N	CBS	08.06.2016

Appendix E. Some facts on selected Universities

Copenhagen Business School (CBS)	**Danmarks Tekniske Universitet (DTU)**
- Founded in 1917 - Broad subject area in the social sciences and humanities - One of the largest business schools in Europe - Ranks #10 among European Business Schools (according to several rankings)	- Founded in 1829 - Internationally recognized - Leading in areas of technical and the natural sciences - Business-oriented approach - Ranks #1 among universities in Nordic Region (according to several rankings) - Persistently increases & develops industry partnerships

(Source: information from respective websites www.dtu.dk and www.cbs.dk)

Appendix F.

Table 3. All Open Externally-Funded Research Agreements in 2014

	KU	AU	SDU	RUC	AAU	DTU	CBS	ITU
A. National Public Sources	**1.961**	**2.435**	**730**	**286**	**1.560**	**1.833**	**120**	**34**
Humanities	148	354	70	89	195	-	-	-
Social Sciences	148	211	81	109	193	-	-	-
Health Sciences	715	483	315	-	108	-	-	-
Technical or Natural Sciences	950	1.375	264	88	1.064	1.833	-	34
Others - Outside of main disciplines	0	12	-	-	-	-	120	-
B. National Private Sources	**1.762**	**2.317**	**848**	**78**	**1.080**	**811**	**76**	**9**
Humanities	95	255	52	23	67	-	-	-
Social Sciences	78	161	66	27	86	-	-	-
Health Sciences	978	1.077	522	-	178	-	-	-
Technical or Natural Sciences	611	819	208	28	749	811	-	9
Others - Outside of main disciplines	0	5	-	-	-	-	76	-
C. EU	**379**	**391**	**159**	**41**	**414**	**560**	**38**	**11**
Humanities	31	42	10	7	24	-	-	-
Social Sciences	14	43	42	13	20	-	-	-
Health Sciences	97	21	30	-	19	-	-	-
Technical or Natural Sciences	237	265	77	21	351	560	-	11
Others - Outside of main disciplines	0	20	-	-	-	-	38	-
D.Other International Sources	**345**	**350**	**127**	**36**	**194**	**438**	**20**	**2**
Humanities	44	51	7	9	23	-	-	-
Social Sciences	23	41	20	12	27	-	-	-
Health Sciences	110	71	71	-	19	-	-	-
Technical or Natural Sciences	168	185	29	15	125	438	-	2
Others - Outside of main disciplines	0	2	-	-	-	-	20	-
TOTAL open Agreements	**4.447**	**5.493**	**1.864**	**441**	**3.248**	**3.642**	**254**	**56**