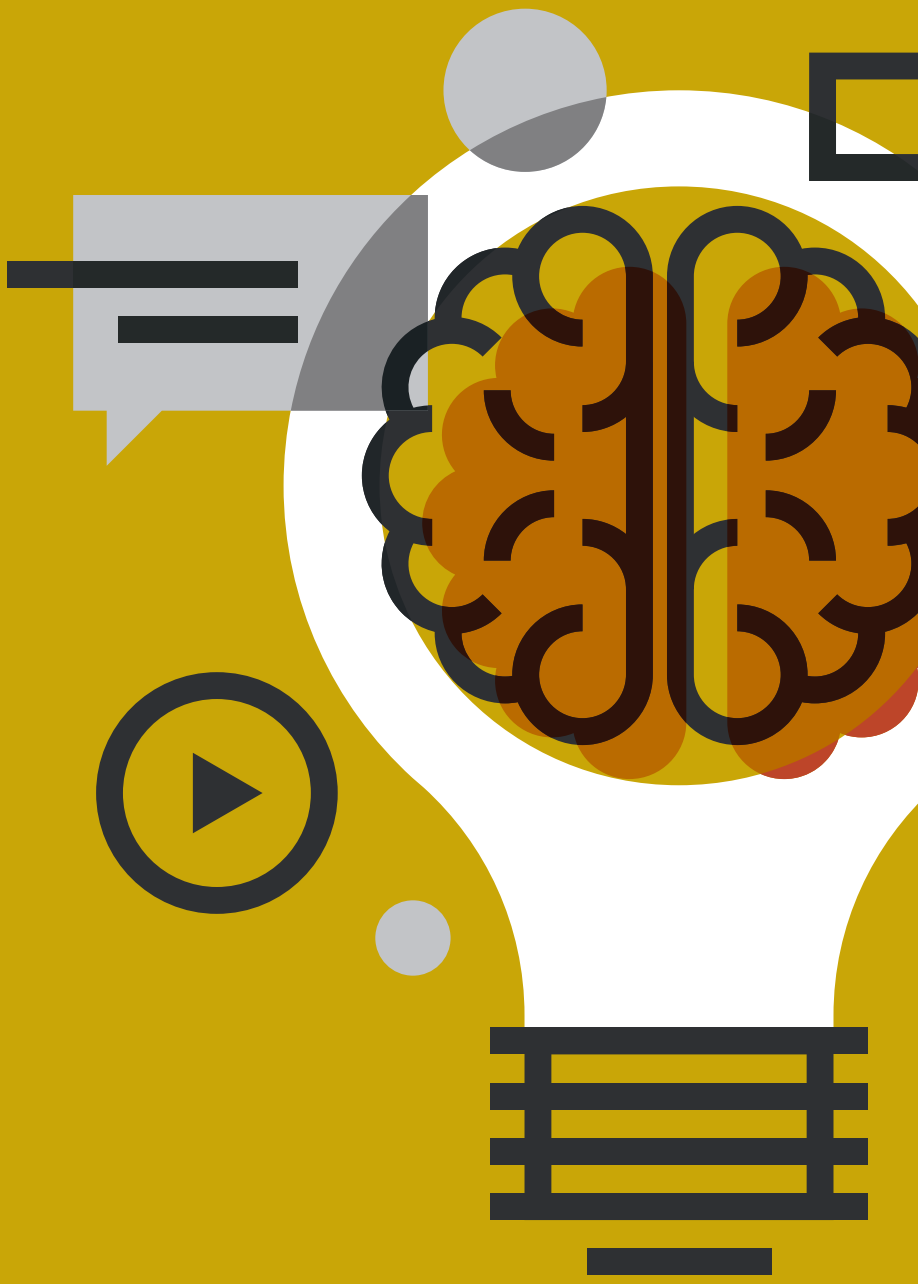
tillväxtanalys

En del av ramprojektet
”Hur kan offentliga aktörer rigga samverkan för ökad innovation?”



PM 2019:06

Exploring university-industry interaction in collaborative R&D projects

HOW DO COLLABORATIVE RESEARCH PROJECTS work in practice: what are the key processes and activities and, what factors enable or impede them? These questions were addressed in interviews with 20 project participants. The results were used to construct a framework for evaluating the processes associated with collaborative research projects. The framework is intended for use by funding agencies.

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Förord

Tillväxtanalys analyserar och utvärderar svensk tillväxtpolitik. Vi ger regeringen och andra aktörer kvalificerade kunskapsunderlag för att utveckla tillväxtpolitiken. Ett allt oftare förekommande tillväxtpolitiskt instrument är program som finansierar forsknings-samverkan mellan akademi och näringsliv. Denna rapport är en delstudie i Tillväxtanalys ramprojekt om samverkan inom tillväxtpolitiken. Ramprojektet har titeln: *Hur kan offentliga aktörer rigga samverkan för ökad innovation*? Följande rapporter har redan publicerats inom detta ramprojekt:

- The effects of innovation subsidies on growth in small firms: What role does collaboration play? (WP 2018:01)
- University-industry collaboration on innovation: a literature review and synthesis (PM 2018:04)

Syftet med föreliggande studie är att analysera organisatoriska problem och utmaningar i samverkansprojekt med deltagare från akademi och näringsliv. I studien undersöks de interaktionsprocesser och aktiviteter som sådana projekt omfattar samt de faktorer som påverkar dessa.

Studien bygger på intervjuer med deltagare i projekt finansierade av två stora samverkansprogram - ett handlagt av Vinnova och ett av KK-stiftelsen. Baserat på studiens resultat presenteras ett underlag för hur samverkansprojekt kan processutvärderas.

Tillväxtanalys vill rikta ett tack till de personer som deltagit i intervjuerna som ligger till grund för studien.

Rapporten har skrivits av fil. dr. Karolin Sjöö, analytiker vid Tillväxtanalys, och Tomas Hellström, professor vid Lunds universitet.

Stockholm, april, 2019

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Sammanfattning

Offentliga forskningsprogram vars syfte är att stimulera samverkan mellan universitets- och högskoleanställda forskare och företag har blivit vanligt förekommande både som forskningspolitiskt instrument och som sätt att adressera diverse komplexa problem i samhället (t.ex. en åldrande befolknings behov av hälso- och sjukvård). Tillväxtanalys har tidigare publicerat en litteraturstudie som sammanfattar vad vi redan vet om de faktorer som möjliggör samverkan mellan universitet och näringsliv. I den tidigare studien ordnades dessa under rubrikerna resurser, universitetsorganisation, funktioner för ”boundary-spanning” mellan universitet och näringsliv, erfarenheter av samarbete, kultur, status och omgivning. Vi kan, baserat på litteraturstudien, konstatera att tidigare forskning typiskt sett studerat möjliggörande faktorer generellt snarare än i anslutning till specifika projekt. Ett annat utmärkande drag är att redan publicerade studier i regel fokuserar på endast en part i samarbetet; antingen universitets- eller näringslivsaktören (typiskt sett den förra). Men studier av generella faktorer gör det svårt att förstå förutsättningar för, och resultatet av, enskilda projekt och ett fokus på endast en part i en relation ger en ofullkomlig bild av de faktorer som påverkar samarbetsprojektet.

I den här studien har vi därför intervjuat både universitets- och näringslivsanställda personer som varit involverade i konkreta samarbetsprojekt. Projekten har valts slumpmässigt ur två projektportföljer; dels projekt finansierade av Vinnovas program Utmaningsdriven Innovation (UDI), dels projekt finansierade av KK-stiftelsens program HÖG. Totalt har tjugo personer som deltagit i tio olika projekt intervjuats. För varje projekt intervjuades en central deltagare från universitet och en från näringslivet. Frågorna som ställdes rörde faktorer som påverkade projektets tillblivelse, det löpande arbetet samt dess mål och resultat. Intervjumaterialet kodades med hjälp av en mall med kategorier härledda från tidigare programteoretisk forskning. Dessa kategorier inkluderar initiering, interaktion, möjliggörande/försvårande faktorer och resultat.

Studiens resultat

Studien visar att universitet- och näringslivsaktörer i regel ger samma bild av hur projekten kom till; det rör sig typiskt sett om att endera tar kontakt med den andra varefter projektidén utvecklas genom diskussioner. När det gäller anledningar att engagera sig i samverkanssprojekt skiljer sig däremot de båda sidorna åt. Medan universitetsanställda pekar på möjligheter att flytta fram sin forskningsposition på områden som är relevanta för samhället, samt att näringslivssamverkan är ett sätt att hålla undervisningen aktuell, menar näringslivsanställda att det framförallt är möjligheter att stärka sin konkurrenskraft som motiverar. Olikheterna är föga förvånande givet de olika typer av institutioner de intervjuade representerar. När det kommer till de faktorer som påverkar projektens tillkomst och det löpande arbetet i forskningssamverkan finns det både likheter och olikheter i de båda sidornas framställningar. Båda sidor framhåller vikten av att målet för samverkan uttrycks på ett tydligt sätt och följs upp kontinuerligt. Dessutom pekas på betydelsen av att förstå ’den andre’ och den logik enligt vilken denne jobbar (tidshorisont, leverabler etc.), samt att etablera en gemensam förståelse av de begrepp och problem som är centrala för projektets framskridande. I andra avseenden skiljer sig de båda sidorna åt; universitetsanställda tenderar att betona sådant som kultur, prioriteringar, stödfunktioner medan näringslivsanställda istället framhåller betydelsen av nätverk, timing, projektägare och strukturer för att hantera eventuella konflikter. De observerade skillnaderna går att härleda till intervjupersonernas institutionella hemhörighet. Resultaten av de studerade projekten beskrivs på olika sätt av de intervjuade kategorierna. Universitetsanställda lyfter fram nya kunskapsperspektiv och forskningsuppslag medan näringslivsanställda istället ser konkreta resultat såsom nya projekt, arbetssätt, ny kunskap om till exempel regelverk eller användarbehov, nya patent eller validering av ny teknik. Vi noterar att de resultat som lyfts fram i regel överensstämmer med de förväntningar parterna hade på projektet alternativt den argumentation som använts för att förankra projektet i hemorganisationen.

Processutvärdering av samverkansprojekt

Baserat på resultaten av intervjustudien föreslås ett underlag för processutvärdering av liknande samverkansprojekt (tabell 1 nedan). Parternas motiv samt den dialog som observerats föranleda ett projekt bör till exempel stå i fokus i en utvärdering av sådana projekts initiering. När det gäller utvärdering av interaktionen inom ett sådant projekt bör uppmärksamheten riktas mot sättet som denna bidrar till lärande. Särskilt intressant är i vilken utsträckning parterna jobbar för att etablera en gemensam förståelse av centrala begrepp och problem, utnyttjar komplementariteter samt underlättar utbyte, utveckling och användning av ny kunskap. Uppmärksamhet bör vidare riktas mot de faktorer som underlättar eller försvårar samverkan, t.ex. tydligheten med vilken dess mål uttrycks, måluppföljning, tidigare erfarenheter av samverkan, parternas nätverk och nyttjande av eventuella stödstrukturer.

Utvärderingsunderlaget kan med fördel användas av myndigheter som handlägger samverkansprogram (t.ex. Vinnova) samt vid ledning och styrning av samverkansprojekt.

Tabell 1 Underlag för processutvärdering av samverkansprojekt

Aspekt	**Fokus och utvärderingsfrågor**
Initiering	Målformulering - Vem initierade projektet? - Hur och av vem formulerades projektets mål? Motivation - Vad har deltagarna för motiv att delta i projektet?
Interaktion	Utformning av projektaktiviteter - Hur utformades projektaktiviteterna och vem deltog i den processen? - Arbetar parterna för att etablera gemensam förståelse av centrala begrepp och problem? I så fall hur? - Finns det kunskap och överblick över kunskapskomplementariteter? - Hur är de aktiviteter utformade som har som syfte att underlätta kunskapsutbyte/-utveckling/-användning?
Påverkansvillkor	Målkonvergens - I vilken utsträckning speglar projektmålet de deltagande parternas förväntningar? Målets tydlighet - Hur tydligt är projektets mål utryckt? - Hur ser måluppföljningen ut? Erfarenhet av samverkan - Vilken tidigare erfarenhet finns hos deltagarna? - Finns det en samverkanskultur på deltagarnas respektive arbetsplatser? - Har deltagarna ett nätverk av samverkansaktörer? Likasinnade projektdeltagare - Vilken förståelse har deltagarna för varandras sammanhang (dvs. prioriteringar, tidshorisont etc.)? Organisatoriska stödfunktioner - Finns det organisationsstrukturer till stöd för projektet? I så fall vilken typ? Hur används de? - Finns det en klar bild av vem som har ansvar för vad i projektet? - Hur hanteras konflikter inom projektet samt internt hos de ingående parterna?
Resultat	Karaktär - Vad har projektet resulterat i? Konkreta? Abstrakta? - I vilken utsträckning motsvarar resultaten deltagarnas förväntningar?

Summary

This paper focuses on how academic researchers and industrial partners view central aspects of the collaboration process in government funded R&D projects. In much previous work on university-industry collaborations (UICs), universities or researchers and/or firms have been studied without any direct reference to the other party, thus neglecting the fact that the motivations, perceptions and actions involved in UICs are two-sided at the least. This study, in contrast builds on interviews with academic-industry project leader pairs to identify how both sides perceive factors in the initiation, interaction, conditions and outcome phases to produce value. While there is unexpected overlap in both parties' perceptions, there is also a clear tendency for academics to stress the less tangible or distant factors (e.g., 'a culture,' 'priorities,' or general university support), while industry actors emphasize more tangible operative factors (e.g., collaborative networks, timing issues, and having project owners and conflict resolution procedures). This might illustrate different cultural or professional mores as well as different notions of what types of efficiencies to seek in project work in general. In this paper, we propose an understanding of collaborations based on the notions of 'productive interactions' and 'translation' that can be utilized as a basis for evaluation frameworks for collaboration programs.

1 Introduction

The purpose of this study is to explore interaction processes and activities and factors that enable or impede them within the context of publicly financed university-industry collaboration projects. The phenomenon of university-industry collaboration (UIC) is on the increase across the world, and research is following this trend with a large number of studies that try to capture patterns, conditions and outcomes for various types of UICs (for overviews see, e.g., Mascarenhas, Ferreira & Marques, 2018; Ankrah & Al-Tabbaa, 2015; Geuna & Muscio, 2009). The bulk of published studies focus on the characteristics of the firms and universities that engage in UICs (Agrawal, 2001) and factors that stimulate its initiation, typically drawing on secondary data (such as the European Innovation Survey) or general surveys targeting a region, one or several research fields, or universities (see Sjöö & Hellström, 2019). Other studies attempt to capture the effects of collaboration (Perkmann et al., 2013) or develop typologies or taxonomies of different UICs (Bonaccorsi & Piccaluga, 1994).

Even though there is increased government support for UICs via directed programs, many of these studies tend to focus on contract research 'in the wild'; in other words, on UICs that are not initiated and circumscribed by any particular policy instrument (e.g., Philbin, 2008). Al-Tabbaa and Ankrah (2016) suggest that an important difference between these two collaboration modalities is that the preconditions of the former 'emerge,' while in the latter case they are 'embedded.' This is a difference that may affect both UIC interactions and outcomes. It is also worth noting that in terms of methodology, earlier studies have tended to capture 'average' conditions or effects rather than those that pertain to a specific collaboration project. In addition, quantitative studies normally account for the character or experience of the involved actors separately, so that universities or researchers and/or firms are studied without any direct reference to the other party (Schartinger et al., 2002). Studies that attempt to capture interactions from a qualitative, case-based perspective similarly tend to focus on only one side of the exchange relationship—either the academic or the corporate—and thus neglect the fact that motivations, perceptions and actions involved in UICs are two-sided at the least (Santoro & Chakrabarti, 2002).

In this study, we] aim to address some of the weaknesses of such approaches by creating three delimitations: first, the design of the study is bound by two collaborative R&D funding schemes, imposing limits on the actors as to the terms and locus of collaboration; second, the actors are interviewed in project pairs of corresponding academic and industrial project leaders, which means that the sample of interviewees includes university-industry partners who actually collaborated; and third, the data collection and analysis are structured so that information about collaboration is elicited for specific aspects of collaboration, namely initiation, interaction, conditions and outcomes (Hellström, 2015). We believe that this design addresses some of the shortcomings of previous work on UICs, and enables a focus on the mechanisms that actually operate in the collaborative process, rather than simply producing general perceptions regarding collaboration, averaged over a great many instances.

In what follows, some of the literature relevant to this issue will be reviewed. Part of this review focuses on approaches for assessing interaction between academic research and users, such as those labeled 'productive interactions', 'contributions' and 'translational research.' Second, we will present the methods employed in the study. This section outlines the 'matched pairs' design of the study, and explains the analytical process model employed in the collection and analysis of data. In the results section we summarize the findings in terms of these relations, focusing on the congruencies and deviations in how university and industry partners engage in collaboration within the four parts of the model. Finally, we discuss these findings from the point of view of the literature, and propose a model for understanding collaborations that can be utilized as a foundation for constructing logic models, program theory, or evaluation frameworks for similar collaboration programs.

2 Overview of the literature

Much of the discussion on UICs has focused on various forms of technology transfer, and has therefore tended to describe exchange relationships that are market-based and relatively 'hands off.' However, in contrast to technology transfer (e.g., the buying and selling of patents, licenses, etc.), participation in collaborative research projects has been argued to require both academic and industrial parties to become 'relationally involved' in order for mutual benefits to materialize (Weckowska, 2015; Perkmann & Walsh, 2007). Perkmann et al. (2013) noted that the scholarly interest in collaborative research projects or research partnerships is relatively new, and in a recent review of the literature de Wit-de Vries and colleagues (2018) found studies that researched the practices of such projects to be very rare. Further, de Wit-de Vries et al. (2019) noted that the few existing studies on collaboration practices focused primarily on academic researchers (e.g., D'Este & Patel, 2007), and not industrial collaborators.

A recent exception is McCabe, Parker, and Cox (2016), who explored how both parties contribute to the joint research project. Based on a large number of interviews with both researchers and industrial partners, the authors suggested a typology of three types of involvement: low, high, and deep. Low involvement denotes a relationship in which researchers are at the helm: the academic side of the partnership performs the majority of the research, while the industry side merely provides data or access to a research site. High involvement describes those relationships in which the industrial partner contributes to the practical aspects of the research, but the researchers are in charge; the division of labor in these projects tends to be lopsided, with industry partners left out of the design, analysis, and write-up of research results. Deep involvement refers to true research partnerships: those in which collaborators contribute to the entire research process on a relatively equal basis by leveraging complementary resources, with frequent meetings between both sides, feedback mechanisms, and mutual attention to communication challenges. Similarly, Cherney (2015) identified three types of industry involvement: the formal supporter, the responsive audience, and the integral partner. The contents of these categories are to a large degree similar to those proposed by McCabe et al. (2016) in that they range from the industry party being minimally involved in the research process, to participating extensively in it. In a comparison of six cases of collaborative research projects, Barnes, Pashby and Gibbons (2002) offered results that exemplify what appears to be the most common situation: namely, a low level of involvement, with industry partners taking on the role of a formal supporter.

Studies like McCabe et al. (2018) and Cherney (2015) have yet to be cross-fertilized with the large body of literature that focuses on factors that hinder or facilitate university-industry interaction. Typically, contributions to this literature center on variables related to the individual, his/her organization, and/or the surrounding environment. On the level of the individual, background and organizational belonging have been found to influence the likelihood and ease of collaboration. A large number of studies have found that the Mertonian norms and values (Merton, 1973) adhered to by the archetypical researcher are incongruent with the market logic that dominates among company employees (e.g., Bruneel, D'Este & Salter, 2010; Corley, Boardman & Bozeman, 2006; Welsh et al., 2008; Schartinger, Schibany & Gassler, 2001). Such differences are related to academic and corporate work routines, as well as to the different timeframes of academic and corporate work (Locket, Kerr & Robinson, 2008; Fontana, Geuna & Matt, 2006; Bozeman et al., 2016). Researchers such as Tartari and Breschi (2012) and Fontana, Geuna and Matt (2006)have addressed the seeming incompatibility between the 'open science' of academia and proprietary approach to research and development taken by companies. The extent to which these differences are related to practical communication challenges and misconceptions or stereotypes about 'the other' should not be underestimated (Siegel, Waldman & Link, 2003; Gertner, Roberts & Charles, 2011; Locket, Kerr & Robinson, 2008). The chief way of overcoming these types of difficulties seems to be to gain collaborative experience (Schartinger et al., 2002; D'Este & Patel, 2007; D'Este & Perkmann, 2011; Tödtling, Lehner & Kaufmann, 2009; Bruneel, D'Este & Salter, 2010). Barnes, Pashby and Gibbons (2002) pointed out that beyond general collaboration experience, previous contact with a particular partner affects the efficiency of the

partnership. Both Barnes, Pashby and Gibbons (2002) and Sherwood and Covin (2008) found that trust built on shared experience is an important success factor in collaboration.

On the organizational level, the availability of resources in the form of time and money has been found to be an important facilitating factor for collaboration (Arvanitis, Kubli & Woerter, 2008; Schofield, 2013; Tartari & Breschi, 2012). Both academics and industrial partners must find time to engage in the joint project and develop mutual engagement and interests (Locket, Kerr & Robinson, 2008; Barnes, Pashby & Gibbons, 2002; Gertner, Roberts & Charles, 2011). The planning and allocation of resources can actively support collaboration via functions such as a technology transfer office (TTO), or simply offer leeway for the individual researcher or employee to engage in collaboration (e.g., Van Looy et al., 2004; Debackere & Veugelers, 2005). Other organizational factors found to influence university-industry interaction include any incentive structures of the organizations involved. Such incentives may be colored by the logic to which the organizations adhere (Bruneel, D'Este & Salter, 2010). Legal and administrative factors are other organizational elements that affect collaboration, although the influence of these remains unclear due to inconsistent empirical evidence (e.g., Franco & Haase, 2015; Caldera & Debande; 2010; Bruneel, D'Este & Salter, 2010; Arvanitis, Kubli & Woerter, 2008).

The environment also plays an important role, and includes the geographical and policy contexts of the interacting partners. Being physically close makes academics and industrial partners more likely to collaborate (Locket, Kerr & Robinson, 2008). However, the influence of proximity seems to be moderated by the character of the collaborators. Being close has been found to be more important for less R&D intensive firms (Laursen, Reichstein & Salter, 2011), as well as for smaller ones (Slavtchev, 2013; Dornbusch & Neuhäusler, 2015). In addition, there are some indications that geographical proximity has a positive influence on the intensity of interaction (Levy, Roux & Wolff, 2009).

2.1 Approaches for assessing interaction

The above factors may be conceived of as metaphorical pathways between academics and practitioners (or 'users'). A number of frameworks for understanding how the gaps in such pathways can be bridged have been suggested in the literature, including 'productive interactions' (e.g., Spaapen & van Drooge, 2011), the 'research contributions framework' (Morton, 2015) and 'translational research' (e.g., Molas-Gallart et al., 2016). Rather than putting the emphasis on outcomes, as has traditionally been the case, the common notion in these approaches is that collaboration can be fruitfully assessed and managed as a process.

The focus of the ''productive interaction'' approach is on the interactions that occur between actors in a collaborative process. Interaction takes place between academics and other stakeholders (and is mediated) via 'tracks' that enable contact, such as research publications, conferences or exhibitions, certain resource arrangements, and, of course, through informal interactions between people. If these tracks are able to mediate interactions that lead to stakeholders applying results, information or experiences to improve some aspect of their activities, then the interaction is deemed productive (Spaapen & van Drooge, 2011). The authors utilize this concept to propose three types of interactions: direct or personal interactions (various connections between individuals); indirect interactions (e.g., through texts such as articles and books, and other artifacts such as films and conferences); and financial interactions (involving money or other kinds of resources). Drawing on several case studies of collaborative innovation efforts, Molas-Gallart and Tang (2011) found a number of common characteristics in these interactions: they are varied in terms of the type of engagement; there is often a clear adaption to stakeholder demands from academics; new interactions tend to flow from previous ones; and the type of interactions tend to evolve over time.

The second approach, the 'research contributions framework', is based on a number of public health research studies (Morton, 2015). It conceptualizes the path from research to social/economic impact as consisting of an initial output from research encountered by users, or an activity that brings together researchers and users. Three main categories of progression typically follow each other in a sequence of increasing levels of utilization: (1) research uptake, which involves creating awareness of, and involvement around, the results of research or research partners; (2) research use, which includes

discernable changes in knowledge and skill among users; and (3) research impact, which involves changes in behavior and practices, including more long-term changes. Morton (2015) argued that empirical attention to these stages makes the construction logic models possible, which describe the progression of contributions in a particular collaborative situation. A central concern in this regard is the learning that takes place as a result of collaboration and knowledge transfer, since this is essential for research impact.

Finally, while the 'research contributions framework' provides a ''phased'' model of collaboration/transfer, another, much better known approach to research-user interaction is that of 'translational research' (Birmingham, 2002). Translational research (TR) is a notion developed in the medical field that assumes, in its most common form, a stepwise progression of knowledge transfer from basic research to clinical trials and, finally, to adoption/evaluation. This concept implies a form of 'gap-centered' approach to the research-user relationship, in which gaps in the chain are identified and addressed so as to improve the translation process (Molas-Gallart et al., 2016). Authors in this tradition have also noted that translations are seldom unidirectional and linear, but often involve iteration/interaction and reversals between stages, such as those captured by Stoke's term 'use-inspired basic research' (Stokes, 1997). One approach for identifying successful translations is focusing on the appearance or non-appearance of certain 'markers' that indicate progress; for example, submission of a research proposal, a published article, a clinical trial, or a market-ready product (Trochim et al., 2011). Molas-Gallart et al. (2016) suggested that various types of proximities between actors in the translation process—for example, between doctors and researchers—are key to understanding how such processes work or fail to work. In line with Boschma (2005), they suggest that cognitive, social, organizational, institutional and geographical proximities (and reverse, distances) have a great influence on how knowledge is transferred across the interactive chain of translation from research to application. Together, these approaches add a process dimension to academic-industry interaction, which allows a more detailed understanding of what happens in such contexts, and thus why collaborations succeed or fail. In what follows, we will describe how this study operationalizes such a perspective to throw light on the mechanisms enabling interaction or collaboration.

3 Method

3.1 Material and design

The empirical material consists of interviews with project leaders/participants in 10 collaborative university-industry projects (20 participants in total). Two Swedish collaborative funding schemes were selected, both of which require collaboration between academic researchers and industrial partners to achieve practical-, utility-, and innovation-oriented outcomes. The first, Development Driven Innovation (UDI), is run by the Swedish Agency for Innovation Systems (Vinnova) and finances up to five years of collaborative research and development intended to further solutions to grand challenges-type problems such as those found in the UN's Agenda 2030. The idea is that collaboration involves interaction throughout the process of ideating/initiating, developing, and testing solutions. The second program is a collaborative scheme (HÖG) funded by the Swedish Knowledge Foundation (KK-Stiftelsen). This program funds collaborative projects of between one and three years in length that deal with distinct problems identified in a university-industry partnership, usually with some direct business application in mind. The projects cover a spectrum of research/innovation areas, ranging from sensors to urban infrastructure, and from medical technologies to factory airflows.

This study draws on interviews with 10 'matched-pairs' from each of the 10 projects: the project leader on the academic and the industrial sides, respectively. The motivation for this design takes as its point of departure the material elaborated in the literature section of this paper regarding collaborative research as a translation process between more basic and more applied actors, in which 'gaps' and 'proximities' play a role (Molas-Galart et al., 2016). By doing so we hope to capture what Spaapen and van Drooge (2011) referred to as 'productive interactions' on the group and individual levels in collaborative projects. This methodology, in which academic researchers and industry representatives working on the same project are interviewed, permits the study of contradictions, complementarities, or the placing of emphasis on different aspects of the collaboration. The matched-pairs design is not expected to generate insight on the level of the pairs as such, but rather represents a sampling strategy for maximizing the visibility and validity of typical or type-level relationships found in the material as a whole by collecting the pairs from the same projects.

3.2 Collection and analysis

Semi-structured interviews were conducted with 20 project participants, all of whom filled a key coordinating role in their projects on either the industrial or the academic side. The interview questions were intended to capture productive interactions among participants along a sequence of stages that such projects typically involve. For the purposes of this study, these are assumed to be:

- The initiation of collaboration (actors, motivations, mechanisms involved).
- Interaction between partners (form of collaboration, structures/processes, facilitators/barriers).
- Conditions for collaboration (general framework conditions not covered in the above topics).
- Outcomes from collaboration (products, new resources, networks, new trajectories).

These categories are derived from the 'action-value attribution framework' (Hellström, 2015; Hansson & Polk, 2018), and summarize various insights from research on program theory, cognitive mapping, and the psychology of attribution to propose a simple model for structuring actors' attribution of value to activities and conditions. The framework focuses on how actions, events and processes (including various framework conditions) are perceived by the actors as having been effective in generating outcomes of various kinds. Interview questions derived from this analytical framework included:

- How was collaboration initiated, and by whom? How was contact made?
- What were the most important forms of collaboration, and how were these enacted in practice?
- What were the most important types of exchange between partners?
- What has been learned from such exchanges?
- What are the most important outcomes of the project?

Interviews were coded according to the above template following the principles of template analysis (King, 1998). The responses were subsequently analytically summarized to form an account of each of the factors from the template (initiation, interaction, conditions, outcomes). We present the results of this exercise below under their respective headings.

4 Results

4.1 Initiation

Initiating a project requires both coming up with a feasible idea and attracting funds to execute that idea. We see two ways in which the ideas that underlie the studied projects emerged. In the first, one actor—a university researcher, an industry representative, a broker (e.g., university grant offices), or someone else who would later become a project participant—develops an idea, and then contacts people he or she believes would be suitable collaborators. Potential collaborators were typically identified in the 'ideators' network, usually among individuals or organizations with which this person had previously been in contact or even collaborated. Only rarely did the initiator make cold calls to prospective partners. In the cases in which he or she had to resort to this strategy, we were told that it had been difficult to identify relevant actors. Only university researchers reported the latter experience. The other way a project idea emerged was through the joint identification of overlapping interests and potential synergies by future project partners. This normally happened in the course of formal or informal networking (e.g., a presentation of research activities, an industry event, etc.), or discussions about other matters (e.g., another joint project). Here too, prior contact between the future collaborators was key to the emergence of the project idea.

The majority of university researchers we interviewed reported having developed ideas and then reaching out to industry partners, whereas industry representatives more often talked about having been contacted by university researchers or the like, and/or the joint identification of ideas. Irrespective of how the idea emerged, both researchers and industry representatives were careful to say that it had been developed and refined through discussions between parties. University researchers commonly drove the process of attracting funds to execute the idea, largely because they had prior experience in writing research grant applications.

The motivations for engaging in collaborations differed between the two categories. Two motives stood out among the university researchers interviewed; first, all spoke about having the opportunity to advance research. Such opportunities were often, however, only mentioned in passing; interviewees spent much more time talking about the possibility of seeing their research results 'do good'. Several researchers spoke of a wish to work ''outside the ivory tower' on 'socially relevant problems'.' Oftentimes, working on problems of such significance was assumed to be a way to achieve both social and academic impacts. Some university researchers saw industry collaborations as key to keeping teaching up to date, and thus as a way to enhance the employability of students.

Industry representatives reported that the possibility of identifying new business opportunities or increasing competitiveness were their main motivations for collaborating with universities. They believed they would achieve this either directly, through the development of new applications of their company's technology, or down the line, through the expansion of personal and/or organizational networks. Collaborating with university researchers was seen as a way to get an in on cutting edge research without having to carry its costs.

4.2 Interaction

Interaction between the interviewed parties took place within a more or less formalized project structure. The complexity of this structure varied with the size of the project (i.e., the number of parties involved): the bigger the project, the more complex the project structure. As an example, one of the bigger projects had a steering committee with both university and industry representatives, and several sub-groups that reported to the committee. The steering committee would, for example, handle primary issues that could not be resolved on the sub-project level. A single project manager more often ran the smaller projects; usually, this person was a university researcher.

Interactions between parties varied in duration and frequency. The majority of interviewees, university researchers and industry representatives alike, described staccato-like interaction over email or in relatively short but intense meetings (face-to-face or using some type of media), in which project results (e.g., prototypes, protocols, etc.), ideas, or other practical project matters were discussed. The

frequency of these meetings ranged from once a week to once every six months. In projects based on this type of interaction, each party generally worked alone between meetings, without too much inter-organizational communication.

In contrast to this short but intense style of interaction, several interviewees described longer-lasting and closer forms of collaboration. Without exception, these accounts revolved around a longer stay by a person employed by a project partner. Arrangements varied; setups in which PhD students and researchers visited firms were more prevalent than the reverse (although this too occurred). One university researcher recounted, for example, how he visited the collaborating firms for weeks at a time in order to conduct measurements. This type of longer 'stay' allowed for everyday communication and relationship-building that shorter meetings did not.

Several of the interviewees—both university researchers and industry representatives—recounted how arriving at a joint understanding of central problems and concepts had been difficult in the early days of the project. Some reported having been aware of its importance and thus dealing with it in a structured way, whereas others described it as an unintended result of discussions. One interviewee, a university researcher with two degrees, viewed acting as a translator between the other parties involved as one of his most important project tasks. Another interviewee, also a university researcher, told how he had initiated the preparation of a dictionary covering central concepts.

4.3 Conditions

Academic and industry actors converged on a number of general points regarding the conditions that supported collaboration. One of the most salient factors mentioned by respondents was that of goal convergence: having common or at least compatible goals for research, or for such goals to converge over time. The academic partners mentioned conceptual goals: for example, how technical concept testing must be of scientific as well as industrial relevance. Both academics and industry spoke of the need for complementarity in terms of substantial subject knowledge, and of R&D competencies, so that the joint effort contributes beyond what can be achieved independently. According to academic respondents, this complementarity was easier to achieve when a project focused on more general-purpose technology, or platform technologies, such that the research insights from studying and developing these could be clearly generalized to other research fields, and not simply to support one particular product. According to the academic representatives, an important condition for this was an industry partner with a strong footing and clear presence in the academic department. Similarly, industry partners reported that common knowledge and joint operative aims were something that developed over time between partners.

Both academics and industry partners supported the notion that goals can never be assumed to develop by themselves; they must be formulated clearly—preferably in the beginning of the project—and the extent to which the project activities adhere to them must be continuously monitored. The project leader plays an important role in enabling and maintaining goal clarity. This might be especially pertinent when it comes to the industrial project leader, since otherwise the project might end up only being conducted on its academic merits, and lose industry relevance; in other words, lose its foothold with the industrial partner. A related issue was also raised by industry project partners: the challenge of handling the difference between industry's and academia's priority preferences (publishing vs. commercializing) and, closely associated with this, how to deal with results with scientific as well as commercial relevance. Even though both sides expressed concern and quoted somewhat negative experiences in this regard, no one offered any clear solutions to this classic dilemma in academic-industry collaboration.

As may be gleaned from the above, convergence of collaborative goals requires the participants to have substantial collaborative experience. This condition is in a way obvious, since experience with something usually leads to better performance. Several participants, however, cited this factor as crucial. Academic partners pointed to a collaborative history—both with the specific partner and with other industrial partners—as a strong facilitating factor in project success. Industry partners emphasized the need for both project partners to have extensive collaborative experience, indicating it

contributed to success. Academic participants also stressed that the project leader must understand 'both sides,' and that this experience comes from previous collaborations, or from having actually worked in both environments for a duration of time; for example by having 'jumped over' to the 'other side' at some point in one's career. One factor mentioned in this regard was the benefit of having an industrial project leader with previous experience as an academic researcher, not just as a collaborative partner. According to the academics, collaborative experience could manifest on a more overarching level as a 'culture of collaboration' in the academic research environment, a result of having long-term involvement with one or several industry partners, and having evolved the department's academic mission in close collaboration with those partners. Industry representatives expressed this more loosely as having 'strong collaborative networks' with academic actors.

Some respondents emphasized how, over time, collaborative experience can develop into a like-mindedness among the partners. Such like-mindedness was considered a powerful factor in support of collaboration, and a way of bypassing negotiation and possible misunderstanding regarding goals and expectations. From industry's perspective, this involved understanding the other side's time horizons; for example, how development and product introduction life cycles create demands on the timing of the project cycle. From academia's side, this was associated with the way in which firms of various types and sizes were different in terms of collaboration. Several respondents, for instance, mentioned how small firms were often able to involve themselves in research projects almost as if they were researchers themselves; in other words, small size enabled closer ties. In both cases, mutual appreciation and understanding were cited as critical factors.

A final condition that must be mentioned is the presence of organizational support structures for collaboration. Academic representatives mentioned central coordinating (administrative) units as beneficial to functioning collaboration, especially when such units could help with contracts, financial issues and Intellectual Property Rights (IPR) concerns. Industry instead mentioned the benefits of organizational solutions for managing possible conflicts, such as steering groups, and having clearly designated internal 'owners' of the project, on the academic as well as on the industry side.

4.4 Outcomes

The most salient type of outcome mentioned by the respondents related to the creation of new knowledge. This is perhaps not surprising given that the focal activity was a research project, but the variation in terms of what counted as new knowledge or insight was significant. Typically, academics emphasized how the collaboration had opened up new research discussions, and thereby created new perspectives on existing knowledge. Collaboration with industry partners led to a deeper understanding of what was already being researched. Industry, in turn, tended to emphasize how interactions with the academic researchers gave them the knowledge to pursue similar projects by themselves and with other researchers; that is, it provided a sort of knowledge platform for further inquiry. Industry representatives, for example, could utilize academic knowledge to argue for new ways of working 'at home'.

More commonly, a tangible knowledge outcome as far as industry was concerned was something related to products and services. One such outcome was new knowledge about the technical demands of user communities; for instance, doctors and medical researchers' requirements for diagnostic equipment, and practical testing of such equipment. Outcomes also involved early awareness of regulatory issues encountered as a result of broader engagement in research networks. Sometimes, the outcome was of a clearly dual-use character—such as an approach to structuring problems—in that it could be academically oriented, but also used by the firm for their processes.

On a few occasions, academics reported that new research directions had opened up as a result of industry project collaborations; that is, the researcher had been able to thematically redirect his or her research in a positive way as a result of the project. As such, learning to master the collaborative project format offers the opportunity to acquire new types of funding (premised on collaboration), and offers the researcher a new role in the academic setting: that of coordinator of collaboration. The corollary to redirection on the industry side was the development of new technology and solutions;

that is, the opportunity for new technology development. This occurred as a consequence of new research results that revealed some new, relevant functionality, or when the acquisition of research derived IPRs enabled new development trajectories. Outcomes could also relate to product improvements, with, typically, the emergence of a general solution that solved one or several problems in an existing product or service offering. A related effect of this kind of industry outcome was that of validation of technology. In these situations, the joint use of industry technologies by the project partners amounted to a kind of reality check for these technologies, and exposed shortcomings in their use.

Access to testing infrastructures also figured among the outcomes; for example, academics mentioned the help they received from industry partners in gaining access to infrastructure and personnel for building testing equipment, and how in return they provided industry with know-how on the technologies. Industry environments were also made available to researchers to conduct tests in the field, such as in a production facility to test research hypotheses. The above outcomes relate to effects on the substantial content of work; i.e., the way research work is carried out. In addition to these, some more intermediary-type outputs were identified related to collaboration. Academics mentioned new project initiation as one typical result of joint project work; that is, a new project is developed and applied for in partnership with the industry partner. Industry talked about this in terms of new research collaborations that resulted from the partnership, and that ensued after project termination, or in parallel with ongoing projects. One example of this was the creation of a national university-industry consortium for the field in question, which was created after project termination. A related benefit mentioned was the practical experience of collaboration with partners, which enabled the firm to position itself in relation to different universities, depending on its specific needs.

Table 1 Results

	Academia	**Industry**
Initiation	Single actor identifies idea - Collaborators identified in network Joint identification of idea - Prior contact between the parties Idea developed and refined through discussions between parties Motivated by opportunities to: - Advance research - Work on socially relevant problems - Keep teaching up to date	One actor identifies idea - Collaborators identified in network Contacted by university researcher Joint identification of idea - Prior contact between the parties Idea developed and refined through discussions between parties Motivated by opportunities to: - Get an 'in' on cutting-edge research without having to carry its costs - Identify business opportunities - Increase competitiveness
Interaction	Co-variation between size and project structure complexity Duration and occurrence of interaction - Staccato-like, short but intense meetings - Long-lasting and close interaction Arriving at a joint understanding of central problems and concepts	Co-variation between size and project structure complexity Duration and occurrence of interaction - Staccato-like, short but intense meetings - Long-lasting and close interaction Arriving at a joint understanding of central problems and concepts
Conditions/ Needs	Goal convergence - Conceptual goals - Complementarity in subject knowledge - Dependent on nature of technology Goal clarity - Formulation and monitoring - Handling of results Collaborative experience - Culture of collaboration Like-mindedness - Understanding how industry priorities affect collaboration Organizational support structures - Central coordinating units	Goal convergence - Complementarity in subject knowledge Goal clarity - Formulation and monitoring - Handling of results Collaborative experience - Strong collaborative network Like-mindedness - Understanding of different time logic Organizational support structures - Structures in place to handle conflicts - Internal 'owners' of project (on both sides)

	Academia	**Industry**
Outcomes	New knowledge - New perspectives on existing knowledge New research directions Access to testing infrastructures New project initiation	New knowledge - Knowledge to pursue similar projects - New ways of working - Knowledge related to regulatory issues - Knowledge about user demands New technological development - IPR - Validation of technology New research collaboration

5 Discussion and conclusions

Contrary to findings by researchers such as Barnes, Pashby and Gibbons (2002), in this study we observed a substantial two-sided involvement between academia and industry. Typically, we saw a mix of the different interaction modes described by McCabe et al. (2016) and Cherney (2015). By dividing the accounts of the interactions into phases, it was possible to identify how this mix was distributed across the various parts of the projects, as well as where the points of tension or obstacles to integration were located (e.g., Molas-Gallart et al., 2016).

To begin with, industry and academia were quite consonant in terms of how the initiation of projects came about. Both sides reported two main approaches: in the first, an actor develops an idea, and then identifies collaborators in a network. In the second, ideas are developed and refined through discussions between the parties, typically after a researcher has initiated contact with industry, or the two parties have met via some other mechanism (e.g., an event, forum or similar occasion). These findings suggest high to deep involvement between the actors in the initiation phase (McCabe et al., 2016).

The actors' motives for initiating a joint project, however, tended to diverge. Academics gave reasons such as advancing research, being able to pursue relevant problems, and keeping teaching up to date. Industry on the other hand seemed to seek insight into cutting-edge research and business opportunities, thereby increasing their competitiveness (e.g., through the development of new applications, or increasing their available competencies through the new networks). This is not surprising, given previous work by researchers such as Bruneel, D'Este and Salter (2010) and Tartari and Breschi (2012) on variations in goals and norms across the two communities. It is notable that while both groups emphasized being on the research frontline as a driver, they also expected utilities from collaboration that were tangible in different ways. Academics wanted to explore areas typically unavailable to them and enrich teaching, while industry sought new products and competences. This suggests that in constructing or incentivizing collaborative projects in the initiating phase, one must be attentive to the parties' differing expectations for utilities from such collaborations, with these typically based on the institutional expectations for their respective activities (Van Looy et al., 2004).

The form and content of interaction were also described quite coherently. Both sides of the collaboration emphasized project size, and the associated complexity in terms of need for coordination. A need to work actively toward a common understanding in terms of shared concepts and aims was emphasized, regardless of project size. This is consonant with previous findings by scholars such as Locket, Kerr and Robinson (2008) and Debackere and Veugelers (2005), who emphasized time for joint engagement and organizational coordination, respectively. In addition, it was interesting to note that both parties described interaction as taking essentially two forms: one that was fast-paced, with short regular meetings for mutual briefings and decisions on direction, and another more long-term and immersive, in which the parties interacted continuously over a longer period. These types of collaborations illustrate what Spaapen and van Drooge (2011) referred to as direct or personal productive interactions. Both these types of interactions were mentioned by each side as being important to collaborative success, which suggests that the possibility of physical proximity is a driver for collaboration (cf. Molas-Gallart et al., 2016; Locket, Kerr & Robinson, 2008).

The industrial and academic representatives converged on a number of points regarding conditions and requirements for successful interaction. They tended, however, to view these aspects a bit differently. Both emphasized the need for the parties to converge on project goals, and the academics specifically tended to underscore conceptual goal convergence. Both sides emphasized goal clarity as this pertained to the formulation and handling of results emanating from the project (Tartari & Breschi, 2012). Both mentioned collaborative experience, but typically the academic side emphasized the development of a culture of collaboration, while industry talked about building up a collaborative network (see Arvanitis, Kubli & Woerter, 2008). Like-mindedness was emphasized by both academics and industry, though in different ways. The academics stressed the need to develop an understanding

of how industrial priorities affect collaboration, while the industry side pointed to the need to develop a mutual perspective on the divergent time-logics involved in science and industry (cf. Locket, Kerr & Robinson, 2008; Bozeman et al., 2016). Finally, both parties stressed the need for organizational support structures, but while the academic side put the focus on central university coordination of projects, industry pointed to the benefits of internal 'owners' of the project who could anchor it in both organizations, as well as structures to handle conflicts during the project. These results essentially cohere with previous research on many points, but what is interesting is how they tended to be expressed differently by the two sides. There was a tendency for the academics to put the stress on the less tangible or distant factors (e.g., 'a culture,' 'priorities,' or general university support), while industry actors emphasized more tangible operative factors (e.g., collaborative networks, timing issues, and the need for project owners and conflict resolution procedures). This might illustrate different cultural or professional mores (e.g., Bruneel, D'Este & Salter, 2010), as well as different notions of what types of efficiencies to seek in project work in general.

Finally, there was a great deal of divergence in the statements regarding observed and valued outcomes from the collaborative projects. Both sides perceived new knowledge as being a valuable result from the projects, but while the academics simply emphasized new perspectives on existing knowledge and new directions for research, the industry side listed a number of more tangible knowledge outcomes. These included knowledge to pursue similar projects, new ways of working, knowledge of regulatory issues and of user demands, and new IPRs and technology validation. Academia offered one similarly tangible outcome— access to research infrastructure—but again, this was more a means to an uncertain end than an end in itself. Both parties mentioned new project initiation (academics) or new collaborations (industry) as valued outcomes, findings that are broadly in line with Ankrah and Al-Tabbaa (2015). The trend here seems to be that academia valued/identified intangible and indirect outcomes, while industry emphasized tangible and direct outcomes. This might be related to the divergent aims of the parties (knowledge creation and profit) and/or with how they justified the value of their participation on the home front. In either event, we see a correspondence in this regard with the motives for establishing collaboration in the first place.

5.1 Implications for evaluation

In the final section of this paper, we will outline some implications of the above findings for assessment (e.g., ex-ante or ex-post evaluations) of collaborative R&D projects of this type (these are summarized in Table 1). Drawing on the above, one might suggest that the primary focus of the assessment of project initiation should be the dialogue that ultimately leads to the elaboration of a project's goals. Since the motivation to engage in collaboration influences its initiation and goals, such assessments ought to pay attention to this element as well. Interaction activities should be assessed according to how they contribute to learning. Special attention should be paid to how adapted such activities are in terms of the development of a joint understanding of central problems and concepts, how they capitalize on knowledge complementarities, and how they facilitate knowledge exchange, development, and utilization. Drawing on the above, the assessment of the conditions that help or hinder collaboration should focus on the goal the collaborators are striving toward: its clarity, monitoring, and the extent to which it reflects both parties' expectations. Evaluation should also center on the collaborative experience of the involved parties, and on the existence and/or development of a collaborative culture or collaboration network. Moreover, exploring the existence and utilization of organizational support structures may explain whether or not a project succeeds. Finally, assessment of project outcomes should focus on their character: their intangibility or tangibility, and their relationship to the parties' expectations and original motivations for collaboration.

Table 2 Evaluation focus and questions

Aspect	Focus and questions
Initiation	Goal formulation - Who initiated the project? - How and by whom were project goals formulated? Motivation - What were the motivations of the involved parties for engaging in the project?
Interaction	Design of project activities - How were project activities designed, and who took part in the design process? - Do the parties work to achieve a joint understanding of central problems and concepts–if so, how? - Are knowledge complementarities mapped? - How are project activities designed to facilitate knowledge exchange/development/utilization
Conditions	Goal convergence - To what extent do the goals reflect the parties' expectations? Goal clarity - How clearly are the goals expressed? - How closely is progress toward the goals monitored? Collaborative experience - What level of collaborative experience do the parties have? - Is there already a collaborative culture in the workplace of the parties? - Do the parties have a collaborative network? Like-mindedness - To what extent do the parties understand each other's context (i.e., priorities, time frame etc.)? Organizational support structures - Are there organizational structures that support the parties? What kind? How are they used? - Is there a clear designation of responsibility for the project in the organizations of the collaborators? - How are conflicts related to the project in and among the involved organizations resolved?
Outcome	Character - What are the outcomes of the project? Intangibles? Tangibles? - To what extent do the outcomes of the project correspond to the parties' expectations?

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