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University-industry collaboration: drivers and barriers

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Abstract

Technology and knowledge transfer often depends on direct collaboration between those who develop new knowledge and those who apply this knowledge. This chapter provides an overview of the phenomenon of university-industry collaboration and the inherent drivers and barriers in this relationship. Many studies show that university-industry collaboration is highly beneficial for the innovativeness and performance of firms. Still, there are many obstacles that hamper effective collaboration between academia and industry. Based on the scientific research in this area, this chapter provides an overview of key drivers and barriers to university-industry collaboration. With particular emphasis on research partnerships, we outline specific drivers and barriers related to the connections between university and industry partners, differences in their organizational culture, the role of organizational characteristics, and the types of relationships. We conclude by providing some suggestions for practice for how to improve university-industry collaborations.

Keywords: Science commercialization, Technology transfer, University-industry collaboration

1. Introduction

Firms have historically organized their research and development (R&D) internally (Mowery, 1983), but firms now increasingly follow an open innovation model by complementing their in-house knowledge through interorganizational collaborations (Hagedoorn, 2002, Chesbrough, 2003, Sampson, 2007). A prominent example is the growing number of university-industry collaborations (UIC)¹ (Caloghirou et al., 2001)², by which universities may contribute relevant expertise and knowledge to a firm's technological resource base and create new possibilities for innovation through research (Mansfield, 1991, Cohen et al., 2002, Dahlander and Gann, 2010).

Conducting research that yields both scientific progress and industrial innovations is challenging for both university and industry partners (Adler et al., 2009, Bruneel et al., 2010, Galán-Muros and Plewa, 2016). In general, firms desire more applied research, while universities strive for basic research (Lee, 2000, Nelson, 2004, D'Este and Perkmann, 2011). This divergence is related to the differing incentive structures and opposing logics of academic research and industrial commercialization (Bjerregaard, 2010, Steinmo, 2015, Galán-Muros and Plewa, 2016).

Although these collaborative challenges are widely acknowledged, prior studies have mainly explored the effects of university-industry links (Perkmann and Walsh, 2007, Wirsih et al., 2016), showing that UIC may lead to successful outcomes such as firm innovations (Mansfield, 1991, Cohen et al., 2002, Robin and Schubert, 2013), patents and licenses (Cohen et al., 2002, Gulbrandsen et al., 2011, Perkmann and Walsh, 2007), products (Kaiser and Kuhn, 2012), and academic publications (Gulbrandsen and Smeby, 2005, Banal-Estañol et al., 2015). Hence, the outcomes of UICs are well known, while the collaborative *dynamics*³ and *processes* leading to these outcomes are less explored (Perkmann and Walsh, 2007, Thune and Gulbrandsen, 2014, Boardman and Bozeman, 2015). There is also limited knowledge of both success factors and how collaborations fail to achieve their targets (Giuliani and Arza, 2009, Bozeman et al., 2013, Steinmo and Rasmussen, 2016). Accordingly, this chapter is guided by the following research question:

¹ UIC' is often used as an umbrella term including all types of 'public research organizations', which are predominantly government-funded, such as universities, research institutes and research centres (e.g., Perkmann and Walsh (2007); Estrada et al. (2016)).

² This development has spurred additional concepts such as the triple helix (Etzkowit and Leydesdorff, 1997) and Mode 2 (Gibbons et al., 1994), which is more concerned with greater demands for the practical relevance of research and science.

³ By dynamics and processes in UIC, this chapter refers to the activities, events, practices and interactions enacted by university and industry partners and how they affect the development of UICs.

“What empirical evidence is available on the development of formal university-industry collaborations aiming at innovation?” By focusing on UICs, the emphasis is therefore on the processes that often precede or follow either the transfer of intellectual property (Perkmann and Walsh, 2007) or commercialization of research (Perkmann et al., 2013).

This chapter continues by defining UIC, before presenting different types of UIC; research partnerships and research services, and the partners’ motives for establishing such UICs. Next, four drivers and barriers of UIC are described. Finally, we provide some reflections and implications for achieving successful UIC.

1.1 Defining university-industry collaboration

The term UIC may appear as self-explanatory and most academic papers do not provide an explicit definition of UIC (Galán-Muros and Plewa, 2016). UIC is often considered as a homogeneous activity, however, in practice there are different collaboration types (Perkmann and Walsh, 2007, Gulbrandsen et al., 2011, Ankrah and Al-Tabbaa, 2015). Hence, it is difficult to provide a definition that covers all types of UIC. The relatively broad definition by Ankrah and Al-Tabbaa (2015, p. 387) defines UIC as “the interaction between any parts of the higher educational system and industry aiming mainly to encourage knowledge and technology exchange”. By focusing on the interaction between university and industry partners and their expected output, the definition covers most collaboration types between universities and industry partners.

1.2 Different types of UIC: Research partnerships and research services

The literature provides several characterizations of UICs (Ankrah and Al-Tabbaa, 2015). Perkmann and Walsh (2007) distinguish between research partnerships and research services based on the degree of finalization of the research undertaken. Finalization refers to whether the research pursue a specific (technical, social or economic) purpose, or if new knowledge is an goal in itself (Perkmann and Walsh, 2007). As such, research services are more applied, while research partnerships entail more basic research.

Research partnerships are designed to generate outputs that are of high academic relevance that can be used in academic publications, and include collaborative research activities, also known as sponsored research and university–industry research centres. Such research partnerships can range from temporary small-scale projects, to large-scale organizations (Perkmann and Walsh,

2007) with up to 50 members, such as in the Norwegian research centres of excellence, the US Engineering Research Centers and the “Cooperative Research Centers” program in Australia (Santoro and Gopalakrishnan, 2001, Boardman, 2012).

Research services are offered by university researchers for industrial clients and tend to be less relevant for academic publications. Contract research and most of academic consulting fall under this category, and involves research or consulting that are carried out by academics but paid for by industry (Perkmann and Walsh, 2007). In research services, there is often less room for academic freedom in research services compared to in research partnerships, because research services target specific objectives and deliverables. Although the boundaries between contract research and consulting is blurred, contract research is generally commissioned to explore specific, previously unresearched challenges, while consulting mainly exploits existing knowledge (Perkmann and Walsh, 2007).

The next subsection explores who establish research partnerships and research services, and what motivate these establishments.

1.2.1 *Who establish research partnerships and research services, and what are their motivations?* Perkmann and Walsh (2009) find that university partners often initiate and set the agenda for research partnerships that contain basic research (low degree of finalization), and that these projects grant more publications for the university partners than more applied collaborations. Accordingly, Lee (2000) and D’Este and Perkmann (2011) find that most academics collaborate with industry to further progress and finance their research and learn from them, rather than to commercialize their knowledge. Hence, university researchers are likely to choose research topics that are (1) perceived to be of interest by their peers, (2) advance the knowledge in their specific area through academic publications, and (3) help them rise up the academic ladder (Nelson, 2004). Hence, new university-industry research centres are often initiated by the university partners.

In contrast, research services that are targeted for problem-solving activities are mostly initiated by firms to obtain assistance from university researchers (Perkmann and Walsh, 2009). Calderini et al. (2007) find that the university researchers who conduct applied research are more likely to produce industrial applications than researchers who conduct basic research. However, applied research leads to fewer academic publications (Perkmann and Walsh, 2009) and therefore

conflicts with the long-term goals of most university researchers (Nelson, 2004, D’Este and Perkmann, 2011, Lee, 2000).

These general findings differ between industries. Firms in science-intensive sectors such as biotechnology, pharmaceuticals and chemicals have strong complementarities between their internal R&D and basic academic research, and tend to rely on research partnerships and to some degree on research services (Meyer-Krahmer and Schmoch, 1998, Cohen et al., 2002, Perkmann and Walsh, 2007). In contrast, sectors that rely less on scientific breakthroughs, such as software development, mechanical engineering, or metals, have a stronger preference for research services (ibid).

The differences between research partnerships and research services may depend on the timing of these activities, where research services are especially required in the latter stages of the innovation process (Polt et al., 2001). Research partnerships, for example in research centres, often leads to research services that are conducted “outside” of the research centre (Lauvås, 2017). A notable implication for firms, is that research services has comparatively lower entry costs than research partnerships, and requires lower levels of absorptive capacity (Perkmann and Walsh, 2007). Also, the fixed cost of specialised personnel and equipment makes research services a good starting point for industry (Perkmann and Walsh, 2008). Hence, firms seeking to engage in collaborations with university partners could start with research services before engaging in research partnerships (Lauvås, 2017). The remainder of this chapter focus on research partnerships between university and industry partners, as these are the most complex types of UIC to handle for both university and firm partners (Perkmann and Walsh, 2007, Lauvås, 2017).

1.3 Drivers and barriers of UIC – and implications for how to succeed

Both sides in a UIC are dependent on each other to obtain access to necessary resources and to generate synergies (Carayol, 2003, Santoro and Chakrabarti, 1999, Lind et al., 2013). Hence, the partners face an inherent challenge by relying on resources from other organizations that are known to have diverse perspectives, interests and objects (Pfeffer and Salancik, 2003, Wry et al., 2013). There are a range of drivers of successful UIC, as well as barriers that makes UIC challenging (Ankrah and Al-Tabbaa, 2015). The realization of the potential benefits of UIC depends on the partners’ ability to overcome such barriers (Bruneel et al., 2010, Plewa et al., 2013b).

To examine the development of UICs, we examine the drivers and barriers along two main dimensions. First, drivers and barriers in UICs may be related to either structural characteristics of the collaboration or to relational issues. Second, some of the drivers and barriers are related to the more general particularities of universities and firms, and are found in UICs in general, while other are collaboration specific issues that relate to the concrete dyadic relation between universities and firms in a particular UIC. Applying this in a two-by-two matrix, we can distinguish between four types of drivers and barriers labelled “connections”, “organisational culture”, “characteristics” and “relationships” as illustrated in Figure 1 and discussed in the following sub-sections.

Fig. 1. Types of barriers and enablers affecting the UIC collaboration process and outcomes

Relational characteristics	Relationships	Organisational cultures
Structural characteristics	Connections	Organizational characteristics
	Collaboration specific issues	General issues

1.3.1 Connections

Three connections between universities and firms have been identified as particularly important for initiating UIC: finding an appropriate partner and social- and geographical proximity. The first challenging step in UIC is to find an appropriate partner (Muscio and Pozzali, 2013). The lack of awareness of, and connections to, potential university and industry partners is found to inhibit UIC (Galán-Muros and Plewa, 2016). In a large scale survey of UK academics, D’Este and Patel (2007) find that the variety and frequency of interactions with industry is not explained by the rankings of the university departments, but rather by the researchers’ individual characteristics. Accordingly, firms are found to judge and choose their university partners at an individual, rather

than an institutional level (Johnston and Huggins, 2018). These findings are in line with the literature on R&D alliances, where organizational-level collaborations often are found to be based on individual members' social relationships (Perkmann and Walsh, 2007).

Social proximity is therefore found to be central in UIC, referring to the actors' relations at the micro-level, involving trust, friendship, and common experiences (Boschma, 2005). Social proximity is generally associated with past collaborations and repeated contacts between partners (Balland, 2011, Huber, 2012, Davids and Frenken, 2017), and is particularly central to the success of UIC innovation projects, and for the continuing of new UICs (Mora-Valentin et al., 2004, Belderbos et al., 2015, Steinmo and Rasmussen, 2016). Hence, UICs is to a large extent based on prior established relationships (Barnes et al., 2002, Mora-Valentin et al., 2004), and although there is limited evidence in the literature on how these relationships are created or maintained (Steinmo and Rasmussen, 2018), Lauvås and Steinmo (2019) recently illustrated that social proximity could be built over time by engaging in activities to build mutual understanding between the partners, such as ad hoc informal contact and industry visits.

Geographical proximity is also found to be of importance in the connection and establishment of UICs (Mora-Valentin et al., 2004), particularly for small firms (Slavtchev, 2013, Dornbusch and Neuhausler, 2015). Steinmo and Rasmussen (2016), in their study of 15 successful innovation projects, found that engineering-based firms tend to rely on geographical and social proximity to universities, while science-based firms rely more heavily on cognitive proximity in establishing UICs. Further, Fitjar and Rodríguez-Pose (2013) find that firms with established collaborative linkages with geographical distant universities and research centres radically increased their innovation potential. These findings implies that science-based firms are more likely to find collaborative university partners across long geographical distances and generate innovations, while engineering-based firms in more peripheral regions with larger distances to universities, would have greater difficulties for engaging in UIC, as it is generally easier to establish UICs with partners in close geographical proximity (Nilsen and Lauvås, 2018).

1.3.2 Relationships

There has been extensive research on the specific relationship-related drivers and barriers in the collaboration process between university and industry partners in UIC, showing the importance of commitment, trust, and ongoing relations.

First, commitment is important in UIC (e.g., Santoro, 2000, Okamuro and Nishimura, 2017), where Knockaert et al. (2014) find that higher involvement in research centers, affect the firms network and competence additionality positively. Further, Okamuro and Nishimura (2017) find that the firm's commitment is important for commercialization in UICs, and Jarvenpaa and Valikangas (2016) found that continued participation over time is important if firms are to influence and reap the benefits from UICs. Lauvås and Steinmo (2019) extended these findings by illustrating that developing proximity along the dimensions of social and cognitive proximity and mutual commitment enabled UIC partners to develop both academic publications and innovations. Moreover, Thune and Gulbrandsen (2014) found that limited firm commitment could lead to “symbolic collaboration”, and high firm exit rates.

Second, trust is critical for developing UICs (Barnes et al., 2002, Mora-Valentin et al., 2004), and is especially important for reducing tensions in UIC (Bruneel et al., 2010). Although university and industry partners may experience a “honeymoon period” in the early stages of the collaboration before their differences surfaces (Estrada et al., 2016), university and industry partners collaborate better over time in successful UICs (Estrada et al., 2016, Lundberg and Andresen, 2012, Steinmo, 2015). Hence, ongoing collaborations may reduce the tensions in UIC over time (Thune, 2011), and because previous collaboration promotes trust in UIC (Bruneel et al., 2010, Lhuillery and Pfister, 2009), building and maintaining trust is an important component for long-term UIC (Bruneel et al., 2010, Galán-Muros and Plewa, 2016). Hence, former collaboration is consistently found as one of the key factors for explaining successful UICs (Bishop et al., 2011, Bruneel et al., 2010, Núñez-Sánchez et al., 2012).

1.3.3 Organizational characteristics

The organizational characteristics are found to matter for the initiation and continuation of UICs, which particularly affect firms ability to absorb research results, and relates to four issues: firm size, firms' absorptive capacity/cognitive proximity, firm representative(s), and openness of research results.

First, the size of the firms matters, where larger firms are most likely to collaborate with universities (Fontana et al., 2006, Roper and Hewitt-Dundas, 2013). In a study of Swedish university-industry research centres, McKelvey et al. (2015) found that the larger firms focused more on knowledge transfer from the centre back to the firm, while the small firms used the

research centre to develop knowledge about customer needs in order to create market opportunities, especially through networking with large firms in the research centre.

Second, Fontana et al. (2006) found that firms with high absorptive capacity more often collaborate with universities, while firms with low absorptive capacity have lower probability of collaborating with universities. When it comes to the similarities in the partners' knowledge bases, or cognitive proximity (Boschma, 2005), similar competencies and capabilities between firms and research partners are found to be important for successful UIC. However, too much similarity may lead to less valuable collaborations because complementary knowledge is required for innovation development (Petruzzelli, 2011). Accordingly, firms with high absorptive capacity and strong knowledge bases are more likely to diffuse the knowledge produced by the universities (Giuliani and Arza, 2009).

Third, firms often struggle to integrate the knowledge of research results because of the knowledge boundaries between firms and universities (Galán-Muros and Plewa, 2016, Alexander et al., 2018, Hayter et al., 2020). Prior research shows that firms are critically dependent on the skills and activities performed by their firm representatives to successfully manage the knowledge stemming from universities (Santoro and Chakrabarti, 2002, Knudsen et al., 2017, Takanashi and Lee, 2018). However, in their study of university-industry research centres, Santoro and Chakrabarti (2002) found that only five of 202 firms had more than one firm representative involved in the research centres' activities. That firms often engage one firm representative in UIC, illustrates the importance of engaging knowledgeable firm representative(s). Hence, the knowledge integration activities performed by the firm representative are found to be important in UIC (Lauvås, 2017), as external knowledge and opportunities often require translation before people inside their organizations can understand them (Cyert and Goodman, 1997, Johansson et al., 2011, Monteiro and Birkinshaw, 2017).

Finally, universities' research results are often openly published, while firms' R&D strategies often involve secrecy and IP protection (Perkmann et al., 2011). Relatedly, firms often fear that confidential information will be disclosed in UICs (Hall et al., 2001), in particular when participating in consortia and research centres with competitors. Hence, to handle the issues of openness of R&D, firms often participate in UICs with competitors to develop knowledge on issues other than their core-technology, researching issues faced by the whole industry, such as regulations and environmental challenges (Jakobsen and Steinmo, 2016, Jakobsen et al., 2019).

Such collaborations often happens in interdisciplinary research centres, seeking to overcome specific challenges in particular industries (Gulbrandsen et al., 2015, Villani et al., 2017) or to tackle some of the ‘Grand Challenges’ facing humanity (Hessels et al., 2014). However, in research centres, as it is for UIC in general, there is a difference in firms motives for participating (Broström, 2012, Fitjar and Rodríguez-Pose, 2013), where large firms often participate in research centres to advance non-core technologies, while small firms want to advance core technologies (Santoro and Chakrabarti, 2002, McKelvey et al., 2015).

1.3.4 Organisational cultures

The large cultural differences between universities and firms have been identified as a barrier for UIC, related to different time horizons, motivations, and communication modes (Steinmo, 2015, Galán-Muros and Plewa, 2016, Bjerregaard, 2010). First, universities often have a long-term orientation, whereas firms are more oriented toward short-term, applied research that can lead to solutions to current problems (Spithoven et al., 2011). This can lead to tensions between university and industry partners (Ambos et al., 2008), and firms’ short-term perspectives are seen as the biggest disadvantage of UICs by university researchers (Meyer-Krahmer and Schmoch, 1998). In contrast, the long-term orientation of universities were seen as a significant barrier by more than two thirds of firms in UK (Bruneel et al., 2010).

Second, firms and university partners have different motivations and R&D requirements (Perkmann and Walsh, 2007, Bjerregaard, 2010, Steinmo, 2015), where firms generally desire applied research⁴ for industrial innovations, and universities basic research for academic publications (Lee, 2000, Nelson, 2004, D’Este and Perkmann, 2011). Third, communication are found to be critical for UIC development and success (Plewa et al., 2013a), but differences in terminology and communication styles are likely to inhibit collaboration (Barnes et al., 2002, Galán-Muros and Plewa, 2016). It is often claimed that academic researchers lack training in communicating their findings outside of academia (Mittion et al., 2007, Galán-Muros and Plewa, 2016).

⁴ Although some science-intensive sectors may prefer basic research, such as pharmaceuticals, this general statement, and the rest of the chapter, corresponds to the R&D preferences of most industrial sectors (Perkmann, et al., 2011; Cohen et al., 2002; Meyer-Krahmer and Schmoch, 1998).

1.4 Implications for practise

This chapter has presented a comprehensive overview of UIC, exploring different types of UIC, and four drivers and barriers of UIC. In conclusion, three areas seem particularly important.

First, the success factors in the UIC-literature are quite general (Thune, 2011, Plewa et al., 2013a), which relates to the general gap in the UIC literature, namely that the collaborative dynamics and processes that reveal how successful outcomes are developed are less explored (Perkmann and Walsh, 2007, Thune and Gulbrandsen, 2014, Boardman and Bozeman, 2015). Hence, it is challenging for firms, universities, scholars and policymakers in UIC to assess and evaluate the success and impact of UICs (Thune, 2011, Perkmann et al., 2011). Especially due to the uncertain nature of basic research, which makes it difficult to set clear objectives and evaluate outcomes that often materialize many years after the UIC have ended (Perkmann et al., 2011). However, because limited insights has been shed on firms innovation portfolio (Nagji and Tuff, 2012), an important realization is that long-term research partnerships (e.g. research centres) may lead into short-term research services, where research partnerships, in for example research centres, often leads to research services that are conducted “outside” of the research centre (Lauvås, 2017, Iglebæk et al., 2018), illustrating the additionality effects of UICs.

Second, while most research on UIC has been conducted in science-based industries such as pharmaceuticals and biotechnology (Lundvall, 2007, Broström, 2012), this chapter has pointed towards some nuances regarding the firm’s size, characteristics and industrial affiliation, and the importance of different dimensions of proximity. Geographical proximity towards universities are found to be particularly important for the establishment of UICs for both small- and engineering based-firms (Slavtchev, 2013, Dornbusch and Neuhausler, 2015, Steinmo and Rasmussen, 2016). Hence, efforts to increase UIC can rely on collaborations with local universities as an important starting point for these types of firms (Steinmo and Rasmussen, 2016, Fitjar and Gjelsvik, 2018). This could be as starting point for increasing the levels of UICs, because former collaboration is one of the key factors for explaining successful UICs (Bishop et al., 2011, Bruneel et al., 2010, Núñez-Sánchez et al., 2012).

Third, firms’ involvement and commitment in UICs are found to be important in building firms’ absorptive capacity and to generate research results that are relevant for both university and firm partners (Santoro and Chakrabarti, 2002, Knudsen et al., 2017, Lauvås and Steinmo, 2019). This is also indicated in the recent report by OECD (2019), which recommend focusing on

knowledge co-creating between universities and industry, rather than a knowledge-transfer approach. For further research, it would thus be important to study such collaboration processes in-depth, to illustrate how different types of firms, both can initiate and participate in UICs, and where the learning could be progressed into new UICs.

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