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Beyond complementarity and substitutability? Understanding relational governance and formal contracts in university-industry collaborations for innovation

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ABSTRACT

Despite recent attention in the literature on the governance of inter-organisational relationships to a process perspective, existing literature tends to neglect the heterogeneity between parties and the various paths and outcomes through which organisations manage to work together towards agreed goals and overcome their conflicts and contradictions. Inter-organisational collaborations for innovation (and university-industry collaborations in particular) involve many trade-offs and a complex process of joint problem-solving and knowledge transfer. We draw on an original survey of university academics and their collaborations for innovation with industry, and employ a configuration approach and fuzzy-set qualitative comparative analysis to explore the interrelated and complex dynamics. We find that in university-industry collaborations aimed at upstream research involving novel scientific knowledge, where goals and deliverables are ambiguous and uncertain, two mechanisms support the collaboration. These include, first, a combination of relational governance and formal contracts and, second, relational governance alone. In contrast, in collaborations for the setting up of spin-offs, where goals and deliverables are specific and clear, only a combination of relational governance and formal contracts supports the collaborations. Formal contracts are always core to facilitating such collaborations. We uncover how different dimensions of relational governance are conducive to the development of, and knowledge transfer in, the different types of collaborations in combination with formal contracts. We thus go beyond debates over the complementarity or substitutability of relational governance and formal contracts in inter-organisational collaborations by exploring in more detail the nature, paths and outcomes of such relationships. We also contribute to extending the university-industry collaboration literature by showing the governance conditions associated with knowledge exchange attributes of different types and phases of university-industry collaborations.

1. Introduction

There is much debate over whether relational governance and formal contracts function as complements or substitutes in inter-organisational collaborations (Poppo and Zenger, 2002; Ryall and Sampson, 2009; Woolthuis et al., 2005). This discussion has particular relevance for inter-organisational collaborations in which there is heterogeneity and multiplicity (Lumineau and Barros De Oliveira, 2018), such as university-industry collaborations where organisations face a degree of complexity that may not exist within collaborations between firms and therefore require us to look more deeply into their challenges and dynamics. In university-industry collaborations, organisations engage in knowledge exchanges but face conflicts regarding the nature of work, including disclosure of research, choice of research topics and time horizons of research (Gulbrandsen and Smeby, 2005; Lee and Miozzo, 2015; Tartari and Breschi, 2012), and regarding the ownership of intellectual property (Clarysse et al., 2007; Rhoten and Powell, 2008). We explore here the interplay of relational governance and formal contracts in supporting university-industry collaborations for innovation.

Research acknowledges that different dimensions of relational governance derived from social capital, such as trust, networks, and shared language (Nahapiet and Ghoshal, 1998), are key in overcoming uncertainty resulting from conflicts in goals and values between organisations in university-industry collaborations (Bruneel et al., 2010;

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Owen-Smith and Powell, 2001; Shane, 2004; Tartari et al., 2012). There is however a lack of consensus about the support provided by relational governance and formal contracts to university-industry collaborations (Al-Tabbaa and Ankrah, 2016; Majuri, 2022; Plewa et al., 2013; Steinmo and Rasmussen, 2018). While relational governance has been acknowledged as supporting university-industry collaborations, the literature on governance suggests that excessive reliance on relational governance can lead to opportunism (Villena et al., 2011), particularly when the collaborations are characterised by high uncertainty and goal ambiguity (Carson et al., 2006). Formal contracts are argued to serve as control tools to safeguard opportunistic behaviour by collaborative partners (Mellewigt et al., 2018; Williamson, 1985), to prevent the exploitation of proprietary technology or avoid information withholding (Alvarez and Barney, 2001; Deeds and Hill, 1998). They can serve as coordination mechanisms in highly complex and uncertain inter-organisational collaborations (Chung et al., 2016; Schepker et al., 2014) to set rules for what to pursue and how to achieve those goals through the collaborations (Ryall and Sampson, 2009).

Emerging literature explores the dynamic interplay between relational governance and formal contracts in inter-organisational collaborations. Attention has been paid to governance match to address different attributes associated with the different types of collaborations (Williamson, 1991), from a longitudinal perspective (Howard et al., 2019; Swärd et al., 2023; Vedel and Geraldi, 2023), or over different phases or aspects of the collaborations (Colm et al., 2020; Hofman et al., 2017). Research however typically assumes inter-organisational relationships to be either cooperative or conflictual, but not as having co-existing cooperative and conflictual aspects (Lumineau and Barros De Oliveira, 2018). In contrast to arm's length transactions, inter-organisational collaborations for innovation (and university-industry collaborations in particular) involve many trade-offs and a complex process of joint problem-solving and knowledge transfer. Yet although understanding the relation between the heterogeneity between the parties and the governance of in inter-organisational collaborations is likely to be important, we still know little about the various paths and outcomes through which organisations manage to work together towards agreed goals and overcome their conflicts and contradictions, and, through such process, develop a common understanding of the inter-organisational relationship (Lumineau and Barros De Oliveira, 2018). A more granular understanding of the governance required to support distinctive knowledge exchange attributes in different types and phases in the process of collaborations is missing. To address this gap, we ask the question: *how do relational governance and formal contracts work together to* support *different types and phases of university-industry collaborations for innovation?*

We acknowledge the complexity in the interrelationship between the various dimensions of relational governance and formal contracts in supporting inter-organisational collaborations. Rather than attempting to untangle how the individual dimensions of relational governance and formal contracts are conducive to the collaborations between universities and firms for innovation, we employ a configuration approach (Ragin, 2008) and a fuzzy-set qualitative comparative analysis (fsQCA) method (Fiss, 2011; Ragin, 2008) to explore their interrelated and complex dynamics. A configuration perspective is suited to exploring organisational outcomes that are complex, multi-faced, causally ambiguous, and that may be better understood through the (multiple) combinations of conditions that are conducive to a given outcome (Fainshmidt et al., 2020; Misangyi et al., 2017).

We explore two polar types of university-industry collaborations for innovation – (upstream) research collaborations and the (downstream) setting up of academic spin-offs. These two types of university-industry collaborations for innovation are characterised by contrasting patterns of knowledge flows and transfer (Poyago-Theotoky et al., 2002; Wright et al., 2008; Davids and Frenken, 2018). We investigate how the interplay of relational governance mechanisms and formal contracts evolves from supporting the development of such inter-organizational collaborations to promoting deliberate efforts of knowledge transfer within them (Steinmo and Rasmussen, 2018).

Our study offers alternative insights that contribute to the literature on the governance of inter-organisational collaborations by contextualising the key mechanisms in the dynamics of collaboration (Lumineau et al., 2023). We find that in university-industry collaborations aimed at upstream research involving novel scientific knowledge, where goals and deliverables are ambiguous and uncertain, two mechanisms support the collaboration. These include, first, a combination of relational governance and formal contracts and, second, relational governance alone (either shared technical language or network as the core condition, depending on the context). In contrast, in collaborations for the setting up of spin-offs, where goals and deliverables are specific and clear, only a combination of relational governance and formal contracts supports the collaborations. Formal contracts are always core to facilitating such collaborations. A key challenge in the evolving dynamics in university-industry collaborations is that the development of the collaborations does not necessarily ensure functional knowledge transfer activities. We uncover how different dimensions of relational governance are conducive to the development of, and knowledge transfer in, the different types of collaborations in combination with formal contracts. We thus go beyond debates over the complementarity or substitutability of relational governance and formal contracts by exploring more detail the nature, paths and outcomes of such inter-organisational relationships (Lumineau and Barros De Oliveira, 2018).

We also contribute to extending the university-industry collaboration literature. We suggest that the existing literature's inconclusive results on the governance of university-industry collaborations (Al-Tabbaa and Ankrah, 2016; Hayter, 2016; Majuri, 2022; Plewa et al., 2013; Steinmo and Rasmussen, 2018) may be explained by a lack of attention to equifinality and to the conjunction of multiple explanatory conditions. The use of configuration approach and the fsQCA method uncovers the multiple pathways and conjunction of different conditions supporting the different types of collaborations and phases in such collaborations. This allows us to focus on the different knowledge exchange attributes associated with different types and phases of university-industry collaborations and the matching governance mechanisms. We show more nuanced combinations of governance conditions.

We discuss next the theoretical background. We then outline the research design and methodology, findings and discussion and conclusions.

2. Theoretical background

Knowledge flows and transfer in collaborations between university and industry face two sets of significant challenges. The first relates to differences in orientations of university and industry (Merton, 1942), and can involve problems of alignment over topics of research, timing and form of disclosure of research results, and threats to academics' freedom of research (Dasgupta and David, 1994; Nelson, 2004). Concerns include the extent to which collaboration with industrial partners could be associated with restrictions for university on the dissemination of research findings, threats to the norm of open science and the possible 'epistemic drift' in short-term target-driven research, at the expense of longer-term research (Gulbrandsen and Smeby, 2005; Lee and Miozzo, 2015; Tartari and Breschi, 2012). The second refers to conflicts over ownership of intellectual property (Siegel et al., 2004), and is argued to arise from attempts by universities to capture the commercial benefits from research and the sometimes unrealistic expectations about these benefits (Clarysse et al., 2007; Rhoten and Powell, 2008). Although ideal typical descriptions of conflicting 'academic logic' and 'commercial

logic' are shown to overstate differences and neglect strong heterogeneity within academic and industrial science (Sauermann and Stephan 2013), these challenges do create a degree of complexity in inter-organizational collaborations that may not exist within collaborations between firms and therefore require us to look more deeply into their challenges and dynamics (He et al., 2021). We explore below the literature on the interplay between relational governance and formal contracts and their role in supporting university-industry collaborations for innovation.

2.1. Relational governance and formal contracts and university-industry collaborations

Relational governance derived from social capital (trust, commitment, prior interpersonal relations and shared knowledge, etc.) is shown to help overcome conflicts and ensure knowledge transfer in inter-organisational relations characterised by uncertainty (Uzzi and Lancaster, 2003; Woolthuis et al., 2005). The categorisation of relational governance is often unclear (Lumineau and Barros De Oliveira, 2018), and typically refers to trust and relational norms. Here we draw on social capital, which stresses the resources rooted in (and assets that can be mobilized through) relationships. Nahapiet and Ghoshal (1998) differentiate the interrelated dimensions of social capital, including relational, structural, and cognitive dimensions. The relational dimension (trust) refers to the personal or emotional attachments/commitments people have developed between each other due to a history of interpersonal relationships built through education, employment, or other social settings, which generates respect, identification, or duty (Granovetter, 1992; Hite, 2005). Such relational commitment reduces uncertainty among individuals in their social relationships (Woolthuis et al., 2005) and can promote close interactions, which is particularly beneficial to the exchange of valuable and tacit knowledge (Dhanaraj et al., 2004). The structural dimension (network) concerns how influential the quality and intensity of social relationships are in terms of providing useful information or command valuable resources (Lin, 2001). Access to gatekeepers of resources indicates a powerful relationship (Grossetti, 2008; Hara and Kanai, 1994). Repeat interactions between individuals indicate a stronger relationship than one-off interactions. Social ties are productive in accessing opportunities for knowledge creation (Nahapiet and Ghoshal, 1998) and knowledge sharing (Wasko and Faraj, 2005). The cognitive dimension (shared language) includes shared technical language, routines and codes, and refers to embedded social relationships that facilitate shared understanding, interpretations and meanings (Kogut and Zander, 1996; Nelson and Winter 1982). Indeed, shared technical language showing knowledge relatedness can be very productive in the acquisition of intellectual capital (Nahapiet and Ghoshal, 1998) because it reduces barriers to learning (Cohen and Levinthal, 1990). Relational governance (trust, network, and shared language) can thus be important as a governance mechanism in inter-organisational collaborations for innovation where parties have conflicting goals (Blomqvist et al., 2005).

Nevertheless, high complexity and uncertainty in inter-organisational collaborations comes with a high propensity of opportunism (Mellewigt et al., 2018; Williamson, 1985), and relational governance may not be immune to this (Villena et al., 2011), particularly when goals are ambiguous (Carson et al., 2006). Relying excessively on relational governance may lead to constraints on decision-making (Li et al., 2013), blindness towards changes (Gu et al., 2008) or unintended consequence of reciprocal obligations towards friends (Chung et al., 2016). Research suggests that formal governance mechanisms such as formal contracts serve as control tools to safeguard opportunism in innovation collaborations, such as exploitation of proprietary technology or information withholding (Alvarez and Barney, 2001; Deeds and Hill, 1998). Formal contracts can function as effective coordination mechanisms when goals are ambiguous (Chung et al., 2016; Schepker et al., 2014). Formal contracts in such instances help define goals/responsibilities and provide structure/clarity within the collaborative relationships when the collaborative outcome is unpredictable and the heterogeneous groups of collaborators hold conflicting values and goals (Chua et al., 2012; Mayer and Argyres, 2004). As such, formal contracts can facilitate a common understanding of what to pursue and how to achieve the goals set for the collaborations (Ryall and Sampson, 2009), and can encourage the longevity of the collaboration and increase the penalties for terminating the collaboration and forfeiting the value of specialised investments (Poppo and Zenger, 2002). In conjunction with relational governance mechanisms, appropriately designed formal contracts can facilitate joint sense-making in the collaborative process in exploratory research collaborations (Faems et al., 2008).

There is much debate about the extent to which relational governance and formal contracts function as complements that reinforce each other, or as substitutes that replace one another in inter-organisational innovation collaborations. On the one hand, research shows that formal contracts reinforce relational governance to mitigate risks and create synergies in inter-organisational collaborations (e.g., Li et al., 2010; Poppo and Zenger, 2002; Ryall and Sampson, 2009). On the other, formal contracts can substitute for relational governance depending on the context, such as when there are potential disputes in the collaborations (Woolthuis et al., 2005) or the collaboration is at the commercialisation stage (de Reuver and Bouwman, 2012). Emerging studies, though rare, explore the dynamic interplay between relational governance and formal contracts beyond their complementarity or substitutability in the governance of inter-organizational collaborative relationships (Lumineau et al., 2023). Research shows that approaching the interplay between relational governance and formal contracts from a single point of time or from a single aspect of the inter-organisational relationships results in limited understanding of the dynamics of how the governance works (Swärd et al., 2023). Distinctive tensions emerge between the partners in different phases – experimentation, integration, and evolution-in the process of solving client problems (Colm et al., 2020), or in early, middle or the late phases of the collaborative relationships (Howard et al., 2019), and the combinations of relational governance and formal contracts supporting such phases often evolve accordingly.

Recent research adopts a more complex process-oriented understanding of the interplay of relational governance and formal contracts supporting inter-organisational collaborations. Broader contractual governance facilitates exploratory research and influences positively the building of goodwill trust, and such positive goodwill trust leads to more flexible contract application at the managerial level, while the contrary can occur with narrower contracts (Faems et al., 2008). Focusing on university-industry collaborations, Steinmo and Rasmussen (2018) show that firms which are experienced in collaborating with universities for innovation first mobilise knowledge relatedness with academics for the development of the collaborative relationships and over time reinforce the collaboration through building mutual goodwill trust, while the opposite sequence occurs with less experienced firms. Notably, not only the parties but also individuals within organisations in an inter-organisational relationship may have divergent values, goals and expectations (Colm et al., 2020), which can influence the evolution of inter-organizational collaboration governance dynamics differently. Howard et al. (2019) find that not only governance mechanisms change as buyer-supplier relationships evolve, but also that the governance mechanisms that are functional for one party may be dysfunctional for the other. In the context of university-industry collaboration, Bercovitz and Tyler (2014) show that scientists pay more attention to knowledge creation and exchange, and build on collaborations based on technological competences. This leads to less detailed subsequent contracts. Contract administrators, by contrast, pay more attention to knowledge protection, and this leads to more detailed subsequent contracts. Interestingly, in such collaborations, Vedel and Geraldi (2023) find that industrial managers use complex governance responses involving

combinations of relational and governance mechanisms at different times to cope with different goals and values between industry and university.

Despite the importance of taking into account the heterogeneity of the organisations and a process view, a granular understanding of the various paths and outcomes through which organisations manage to work together towards agreed goals and overcome their conflicts and contradictions is lacking. A key challenge in the evolving dynamics in university-industry collaborations is that the development of the collaborations does not necessarily ensure functional knowledge transfer activities (Clarysse et al., 2007). Knowledge transfer activities in university-industry collaborations require extra efforts (De Luca and Atuahene-Gima, 2007; He et al., 2021; Zahra et al., 2000). While having knowledge transfer activities is a desired outcome of university-industry collaborations, it is also a critical phase in the collaborations because it is at this point that the conflicts and tension between academics and industry in terms of the nature of work and of ownership of intellectual property are more likely to surface and improvements in the collaboration may be required. Therefore, a process view which differentiates the governance required to support distinctive knowledge exchange attributes in different phases of the collaborations is required.

2.2. Interplay of relational governance and formal contracts and heterogeneity of university-industry collaborations

Few studies address explicitly the combined influence of different dimensions of relational governance on university-industry collaborations. Those that do, however, reach very different conclusions. On the one hand, some studies show that the structural dimension of relational governance, such as quality and strength of networks, social ties and interpersonal relations, is relatively more influential than the other dimensions of relational governance. Indeed, drawing on university-industry research projects funded by the Australian Research Council, Plewa et al. (2013) show the critical role of prior interpersonal relations, and the limited influence of trust, at every stage of the collaborations, from initiating, engaging in, to maintaining the collaborations. Majuri (2022) reaches a similar conclusion regarding the influence of relational governance on R&D consortiums partly funded by Finland's largest public funding agency. Furthermore, Grossetti (2008) shows the importance of social ties in the form of access to a gatekeeper in initiating a university-industry joint research in France. On the other hand, other studies find limited influence of interpersonal relations. Exploring the role of the various dimensions of relational governance on the UK Faraday Partnerships between university and industry to solve specific industrial problems, Al-Tabbaa and Ankrah (2016) find that prior interpersonal relations are less prominent in the pre-formation stage of the partnerships, while trust remains important throughout the different phases of the collaborations. Similarly, Hayter (2016) show limited interpersonal relations between entrepreneurial academics and professional services firms in the setting up of academic spin-offs.

There are also conflicting views on the role of shared knowledge. Studies reveal that a lack of shared technological understanding results in challenges in terms of the performance of university-industry collaborations for innovation due to problems of communication and interpretation (Al-Tabbaa and Ankrah, 2016). Yet, Majuri (2022) find no positive associations between shared understanding and knowledge transfer activities between universities and firms.

The results of the different studies are contradictory and inconclusive at best. It is difficult to reconcile different insights regarding the governance of university-industry collaborations for innovation because the literature either focuses on the aggregate level of university-industry collaborations for innovation, explores a specific type of collaboration, assesses the net effect of a specific dimension of relational governance, or considers the optimal route conducive to such collaborations. Moreover, literature on the interplay between relational governance and formal contracts governing university-industry collaborations is scarce. Exceptions include Clauss and Kesting (2017), who show a positive net influence of relational mechanisms and a negative net influence of formal contracts on knowledge sharing, and the above study by Vedel and Geraldi (2023), who unveil the interplay between relational governance and formal contracts from the perspective of industrial managers.

One problem that obfuscates our understanding of the role of governance mechanisms on university-industry collaborations is that university-industry collaborations are very diverse, ranging from in the upstream innovation process where firms seek to develop breakthrough basic scientific knowledge with universities which is typically distant from the firms' main knowledge domains (Davids and Frenken, 2018), to the downstream innovation process where entrepreneurial academics source knowledge from industry for academic spin-offs to commercialise their research (Hayter, 2016; Lee and Miozzo, 2019). In between, academics may offer knowledge to industrial members of research consortiums or carry out consultancy projects sponsored by industry to solve specific industrial problems based on applied scientific knowledge with clear industrial applications (Perkmann et al., 2011; Schartinger et al., 2002). Different types of university-industry collaborations have different attributes in terms of perceived uncertainty, goals, knowledge production, and patterns of knowledge transfer (Poyago-Theotoky et al., 2002; Rothaermel et al., 2007; Schartinger et al., 2002; Thursby and Thursby, 2002; Wright et al., 2008). Due to the heterogeneous knowledge exchange attributes associated with different types of university-industry collaborations, we expect a complex governance match (Colm et al., 2020; Hofman et al., 2017).

Given the complexity in the interrelationship between the relational governance and formal contracts, governance scholars call for the use of more diverse methodologies to explore their interrelations (Lumineau et al., 2023). We adopt a configuration approach using the fsQCA method to explore this interrelated and complex dynamics. We investigate: 1) a more nuanced account of the interrelatedness (and exact combinations) of the relational governance and formal contracts conducive to different types of university-industry collaborations in different phases of the collaborations, and 2) equifinality of (the multiple sets of) combinations of the relational governance and formal contracts conducive to the university-industry collaborations.

3. Methodology

3.1. Research setting

To address the inter-relatedness and context-specificity of the combinations of relational governance and formal contracts, we compare two types of university-industry collaborations for innovation with contrasting patterns of knowledge flows (Poyago-Theotoky et al., 2002; Wright et al., 2008) – research collaborations and the setting up of academic spin-offs, which represent some of the most significant channels of academic engagement and commercialisation (Perkmann et al., 2011; Schartinger et al., 2002).[1] While the two types of collaborations between

[1] University-industry relations include formal relationships—such as university spin-offs, licensing, collaborative research with industry, contract research by industry, research consortia, and consulting—and informal relationships—such as graduate mobility, conferences, informal meetings, and joint publications. The UK Higher Education Statistics Agency (HESA) data shows that in the year 2021-22, income from collaborative research with industry (fully- or partly-sponsored by public funding) was the highest among all formal relationships between universities and industry (https://www.hesa.ac.uk/data-and-analysis/business-community, accessed on 11 Dec 2023). Similarly, according to the online enterprise data platform Beauhurst, the investment received by the UK academic spin-offs from the public Innovate UK grants, the biggest investor of UK academic spin-offs, increased from £2 m in 2012 to £95.2 m in 2020 (https://raeng.org.uk/policy-and-resources/research-and-innovation/accelerating-enterprise, accessed on 17 March 2023).

university and industry are high in government research impact agendas and are increasingly institutionalised as academic performance indicators (Antonelli, 2008), they are often included under the same general umbrella. Nevertheless, they involve different flows of tacit and explicit knowledge (Poyago-Theotoky et al., 2002; Rothaermel et al., 2007; Schartinger et al., 2002; Thursby and Thursby, 2002; Wright et al., 2008). They are also situated at the two ends of the innovation development process. Research collaborations to develop scientific breakthroughs take place upstream and draw heavily on partly explicit (scientific) knowledge (Davids and Frenken, 2018). In contrast, collaborations to set up spin-offs, typically designed to turn prototypes into functioning products or service in the market, are downstream and involve knowledge that is more tacit and contextual. By focusing on collaborations which exemplify contrasting knowledge production dynamics, we address a blind spot in studies of inter-organisational collaborations that often focuses on an aggregate or single type of collaborations (Lumineau and Barros De Oliveira, 2018).

We focus on collaborations between universities and professional services firms. Professional services firms offer a useful empirical context to explore the conditions conducive to knowledge transfer in collaborations for innovation between universities and firms because of their knowledge intensity (Miozzo et al., 2016).[2] In research collaborations between universities and firms, professional services firms act as knowledge 'seekers' (Audretsch and Betiski, 2019; Lee and Miozzo, 2019; Mina et al., 2014), exploring the commercial potential of the risky, uncertain but novel scientific research, which is often still in its infancy regarding commercial application. In these collaborations, goals and deliverable milestones are typically ambiguous. While the explicit scientific knowledge may be made freely available (for example, in the form of scientific publications), it is highly uncertain whether the firms can reproduce and make this scientific knowledge work specifically for them (He et al., 2021; Vedel and Geraldi, 2023). Firms often seek to secure ownership of the intellectual property rights (IPRs) and to internalise and develop further the (largely) explicit knowledge from the collaborations within the firms (Antonelli, 2008; Hall et al., 2001). Examples of such collaborations include financial services firms collaborating with universities on the development of cutting-edge blockchain technology to facilitate secure transactions for their clients, and on artificial intelligence to transform the way the firms engage with clients.

Instead, in innovation collaborations designed to set up academic spin-offs, academics are interested in commercialising their research, exploiting their patented or unpatented scientific research outputs in tradable products in the market for financial rewards (Shane, 2004). Lacking the necessary commercialisation knowledge (including professional knowledge on management team formation, business strategy formulation, marketing and sales or technological knowledge for prototyping and testing) (Hayter, 2016), academics seek expert knowledge, often tacit and embodied in consultants from professional services firms (von Nordenflycht, 2010), to realise the commercialisation procedures. Here, goals and deliverable milestones for the collaborations are specific and clear (Hayter, 2016). Professional services firms can 'feed' entrepreneurial academics with knowledge and enabling resources relating to product development and commercialisation of science, helping university spin-offs fill 'knowledge gaps' of different types in downstream innovation development (Lockett et al., 2005). Examples of such collaborations include law firms' advice on IP or management consultancy firms' assistance on business strategy for entrepreneurial academics (Clayton et al., 2018).

While collaborations for upstream research and to set up spin-offs have distinctive objectives and patterns of flows of explicit or tacit knowledge,[3] knowledge transfer between collaboration partners, however, may require further deliberate efforts. Various studies explore the mechanisms of knowledge transfer. Nonaka (1994) proposes that the transfer of explicit (codifiable) knowledge may involve deliberate learning mechanisms such as the 'combination' of explicit knowledge from individuals. Explicit knowledge transferred through 'combination' remains largely explicit, and the process is facilitated through mechanisms such as meetings and the documentation of knowledge. In contrast, the conversion of explicit knowledge into tacit knowledge (which has a personal- and context-specific quality that makes it difficult to formalise or communicate), requires deliberate 'internalisation' mechanisms, such as learning-by-doing and experimentation (Nonaka, 1994). Also, the conversion of tacit knowledge into explicit knowledge is referred to by Grant (1996) as 'expert direction'— comprising rules and directives given by specialists to guide the actions of non-specialists or specialists in other fields. Finally, tacit knowledge may also be converted into tacit knowledge through 'socialisation' (Nonaka, 1994), facilitated by interactions between individuals, such as imitation, observation and practice.

Research collaborations between universities and firms normally rely on the transfer of largely explicit (scientific) knowledge (into explicit and/or tacit knowledge) (Davids and Frenken, 2018; Wright et al., 2008). In contrast, collaborations to set up spin-offs rely on the transfer of tacit knowledge because fewer elements of scientific knowledge or the transfer of IP (Wright et al., 2008). Firms provide instead 'soft science', including advice, business intelligence, networks, and entrepreneurial support for the spin-offs (Clayton et al., 2018). These relationships involve academics seeking to gain access to commercialisation knowledge (Poyago-Theotoky et al., 2002), rather than acquire, internalise and develop further specialisation in this knowledge (Grant and Baden-Fuller, 2004). As such we would expect that it is the academics' action on 'expert direction', based on the specialist knowledge of the consultants, that plays as a predominant mechanism in knowledge transfer in this type of collaborations.

We summarise the attributes of the two types of university-industry collaborations and the associated mechanisms that enhance knowledge flows in Table 1. We expect that multiple sets of combinations of relational governance dimensions and formal contracts facilitate the development of, as well as knowledge transfer in, the different types of university-industry collaborations.

3.2. Research design

We used the fsQCA technique in an inductive theory elaboration effort to reevaluate existing theories in a configurational manner (Misangyi et al., 2017; Park et al., 2020).[4] We followed best practices recommended for applying the fsQCA technique (Greckhamer et al., 2018). First, we drew on survey data collected through the guidance of theory for a systematic identification of configurations of conditions leading to the outcomes (Meuer, 2017; Park et al., 2020). Second, we

[2] Professional services firms are based on highly specialised skills and knowledge—this includes social and institutional knowledge, as in many traditional professional services such as law firms, accountancy or management consultancy, or technological knowledge, such as computer, R&D, and engineering services (Miles, 2005; Miozzo and Soete, 2001; von Nordenflycht, 2010).

[3] We acknowledge that although there are great differences between research collaborations and spin-offs, there are also connections and overlaps between them. Spin-offs can be intended or unintended outcomes of research collaborations, because research collaborations may offer insights into commercial opportunities available to academics for their scientific discoveries or provide them the possibility of developing innovations that can be commercialised (Perkmann et al., 2013). Additionally, research collaborations may involve spin-offs working together with the academic lab they spun out from (Meyer, 2003).

[4] fsQCA also has limitations compared to other more traditional qualitative methods. In particular, the static comparisons are relevant for clarifying what combinations matter, but not to illuminate the process through which these combinations come about (Livne-Tarandach et al., 2015).

Table 1
Attributes of research collaborations and setting up of university spin-offs.

	Example of collaboration	
	Research collaborations	Setting up of university spin-offs
Stage in innovation development process	Upstream	Downstream
Goals and deliverable milestones in the collaboration	Uncertain and ambiguous	Specific and clear
Roles of the firm	Knowledge seeker	Knowledge feeder
Main type of knowledge to be converted	Largely explicit	Largely tacit
Motivation for knowledge transfer	(For the firm) To acquire novel (university) knowledge	(For university) To access soft knowledge (from professional services firm)
Major efforts of knowledge transfer	Combination (by the firm) Internalisation (by the firm)	Expert direction (from professional services firm/expert to university spin-off)

returned to case-level analysis representing configurations linked to the outcome of interest for richer knowledge about the configurations when interpreting findings (e.g., Campbell et al., 2016). To achieve this, we utilised supplementary interview data for a deeper understanding of the configurations (Ordanini et al., 2014; Speldekamp et al., 2020; Mellewigt et al., 2018). We contacted respondents that matched the configurations identified in the fsQCA analysis for semi-structured interviews to gain in-depth knowledge (Wilhelm et al., 2021; Mellewigt et al., 2018). We gathered the data between November 2018 and February 2019.

3.3. Sample

To explore systemically the configurations that support knowledge flows and transfer in university-industry collaborations for innovations, we focused on collaborations for innovation between leading universities and professional services firms. We selected our sample from the list of collaborative research projects sponsored by the Engineering and Physical Sciences Research Council (EPSRC) between universities and professional services firms. EPSRC, the main UK research funding agency for engineering and physical sciences, is the largest funder among the UK Research Councils. EPSRC grant holders are mostly from research-intensive universities (D'Este et al., 2013). We focused on academics and professional services firms involved in EPSRC-sponsored projects to ensure that research collaborations in our study were driven by breakthrough research representing the fuzzy front-end of the upstream innovation activities.

For collaborations to set up spin-offs, we focused on a list of academics from two leading research-based UK universities based in London (Imperial College London and University College London) who set up spin-off companies. These universities are top research-based universities renowned for breakthroughs in the fields of science and engineering, and have a higher level of academic spin-off activities (see Lawton Smith et al., 2014), providing rich information to compare and contrast the two types of activities by academics and their collaborations with industry. Also, these universities provide comprehensive information about their academic spin-offs via their centralised TTOs in official websites, providing a good source of data triangulation. The combination of strategies helped identify a varied set of rich collaborations, comprising contrasting goals and patterns of knowledge flows (Davids and Frenken, 2018; Wright et al., 2008). The theoretical sampling strategy is particularly suited for uncovering relationships among constructs (Eisenhardt and Graebner, 2007).

3.4. Survey

From the sampling frame, we identified and collected contact details for 281 academics: 128 academics collaborated with professional services firms in EPSRC projects and 153 academics had set up spin-offs. An original questionnaire was developed and pilot-tested with three academics involved in research collaborations with firms, two who had set up spin-offs, and two specialised in academic engagement and commercialisation. The rating of the various constructs in the questionnaire appears to be consistent with our discussion of the constructs perceived by these academics. The survey received 29 responses from the former group and 24 responses from the latter (the survey was conducted via telephone; see Appendix Table A1 for the demographics of respondents). The overall response rate was 19%.[5] We asked each of the academics collaborating with professional services firms in EPSRC projects to identify a firm that was involved in one or more of their collaborative projects and describe their collaborations with the firm. We asked each of the academics who set up a university spin-off to identify up to two professional services firms that had the most impact on the spin-off and describe their collaborations with the firms.[6] This process yielded data for 58 collaborations between universities and professional services firms for analysis. We map our research process in Appendix Figure B1.

3.5. The fsQCA method

We applied the fsQCA technique (Ragin, 2008) to analyse the data. The fsQCA technique connects qualitative and quantitative approaches. It is tied to case-based research, which allows researchers to gain more case insights within the context. At the same time, it is developed to formalise patterns of similarities and differences across cases, ranging from small to very large sample size, based on set theory using Boolean algebra, allowing for 'modest generalisation' (Rihoux and Ragin, 2009). It explains how an outcome can be understood by combinations of (membership of) explanatory conditions. Analysis using the fsQCA technique does not determine causality, but provides logically possible (multiple) combinations of explanatory conditions connected to a specific outcome based on conjunctural causation. As such, the fsQCA method has several distinctive characteristics. First, there can be multiple sets of combinations of explanatory conditions leading to a single outcome. Thus, fsQCA is useful in explaining 'equifinality' (Crilly, 2011; Fiss, 2011), meaning that different explanatory conditions and alternative configurations of such conditions may be associated with the presence of an outcome of interest. Second, fsQCA is powerful in addressing complex reality when multiple explanatory conditions are believed to act interdependently, because, with this method, the outcome of an event is produced through a conjunction of multiple

[5] The response rate is comparable to recent surveys reported in academic journals (e.g., Miozzo et al., 2016). However, we notice that our respondents and interviewees were highly experienced and several acted as champions for their department/faculty/university in academic engagement and commercialisation. Our data are therefore likely to be oriented towards expert views, which in turn provide in-depth insights into the relationships.

[6] We asked entrepreneurial academics to identify up to two professional services firms in order to capture more diverse insights into the functions that professional services firms may perform to support the setting up of university spin-offs.

explanatory conditions rather than on a single cause (conjunctural causation). As such, solutions to an outcome uncover the combination and the interchangeability of explanatory conditions relevant to the outcome (Fiss, 2011). Third, fsQCA allows for causal asymmetry (Fiss, 2011), meaning that solutions for the presence and absence of an outcome do not need to be the inverse of each other.[7] Because we intend to go beyond the debate regarding substitutability or complementarity and uncover richer and nuanced dynamics of the interrelatedness of the various relational governance dimensions and formal contracts conducive to university-industry collaborations, we applied fsQCA to explore this complex, causally ambiguous phenomena.

3.6. Outcome measures

We assess how different dimensions of relational governance and formal contracts influence different types of collaborations between universities and firms. The first outcome measure indicates whether the collaborations are for research or instead provide support for setting up university spin-offs. We constructed a dichotomous measure 'Research collaborations', which was coded 1 if it was a research collaboration and 0 otherwise. We label the negation of 'Research collaborations' as 'Spin-offs', which was coded 1 if the collaboration involved setting up academic spin-offs, and 0 otherwise.[8] Among the 58 collaborations included in the analysis, 29 were research collaborations and 29 involved setting up spin-offs.

We further assess how relational governance and formal contracts influence knowledge transfer in each type of collaborations. We developed two outcome measures as proxies of deliberate efforts of knowledge transfer in the collaborations. We adopted items from the literature on knowledge integration (De Luca and Atuahene-Gima, 2007; Zahra et al., 2000) and knowledge conversion (Grant, 1996; Nonaka, 1994). We asked each academic to score from 1 to 5 the extent to which the academic and the firm used each of the following activities to capture, interpret, and integrate knowledge created in the collaborative relationship (1 = never used; 5 = widely used): 1) consultants or technical experts to synthesise knowledge; 2) regular formal reports and memos that summarise the knowledge exchanged; 3) information-sharing meetings; 4) face-to-face discussion between both parties; and 5) placement of project researchers in the company. An outcome measure 'Knowledge transfer through spin-offs' was created using the first item, indicating the intensity of the use of rules or directives by experts in the collaborations. We interpret this as evidence of efforts in converting tacit knowledge into largely explicit knowledge in the form of 'expert direction' for the spin-off to follow (Grant, 1996). Items 2–5 were used to construct an exploratory index 'Knowledge transfer through research collaborations' (Cronbach's alpha = 0.676; CR = 0.731; AVE = 0.435). These items indicate evidence of deliberate efforts in the transfer of largely explicit knowledge into explicit knowledge for firms through meetings and documentation, and into tacit knowledge through internalisation, such as learning-by-doing through researcher mobility, as theorised by Nonaka (1994).[9]

3.7. Explanatory conditions

We constructed three measures as proxies for the relational governance dimensions. A first measure, 'Trust', an index, is a proxy for relational/interpersonal dimension of relational governance, capturing information on mutual commitments/goodwill trust (Nahapiet and Ghoshal, 1998; Tsai and Ghoshal, 1998) based on the question with statements: 1) we were equally willing to put effort into something that we asked each other to do; and 2) we were equally willing to share technical information with each other (Heringa et al., 2014; Huber, 2012) (Cronbach's alpha = 0.812; CR = 0.824; AVE = 0.701). A second measure, 'Shared language', an index, is a proxy for cognitive dimension of relational governance capturing information on resources that provide shared understanding and meaning (Nahapiet and Ghoshal, 1998), based on a survey question that asks each academic to indicate, from 1 to 5, their agreement with each of the following statements with respect to their collaborations with the firm (1 = strongly disagree; 5 = strongly agree): 1) we used a similar technical language; and 2) we shared a common expertise (Heringa et al., 2014; Huber, 2012; Nooteboom et al., 2007) (Cronbach's alpha = 0.813; CR = 0.825; AVE = 0.716). Finally, following literature on the influence of network features such as gatekeepers and repeat interactions as initiation enablers on inter-organisational collaborations (Grossetti, 2008; Hara and Kanai, 1994; Hauschildt and Kirchmann, 2001; Lin, 2001), we asked each academic to indicate: 1) whether they had worked with the firm previously in other projects (yes = 1, no = 0); and 2) whether he/she had had a professional relationship with project leaders/gatekeepers in the firm prior to the collaboration (yes = 1 and no = 0). Thus, a third explanatory condition, 'Network', is a proxy capturing information on quality and strength of interpersonal relationships (Tsai and Ghoshal, 1998), the structural dimension of relational governance (Nahapiet and Ghoshal, 1998), which equals 1 if the answer is yes for either of the questions, showing a stronger prior working or professional relationship between the academic and the firm, and 0 otherwise.[10]

We constructed a fourth measure, 'Contract', an index, as a proxy for formal contracts, based on the same survey question that asks each academic to indicate, from 1 to 5, their agreement with the following two statements about their collaborations with the firm (1 = strongly disagree; 5 = strongly agree): 1) the behaviour of both parties in this collaboration was governed by a written contract; and 2) the contract with this company stated precisely the activities to be performed in this collaboration (Clauss and Kesting, 2017; Li et al., 2010) (Cronbach's alpha = 0.902; CR = 0.911; AVE = 0. 838).

[7] The method is fundamentally different from the variance-based regression analysis based on linear algebra to assess effects of individual independent variables. As such, fsQCA has no omitted variable bias in the same way that regression analysis encounters and can be applied to a sample of all sizes (Fainshmidt et al., 2020; Misangyi et al., 2017). Furthermore, although regression analysis with interaction terms may address complementarity or substitutability of independent variables, interaction terms with more than two independent variables become extremely difficult to interpret.

[8] It is not necessary that the inverse of explanatory conditions for an outcome must be the explanatory conditions for the absence of the outcome. For example, Fiss (2011) shows that very high firm performance can be achieved by cost-leaders with a complex organisational structure in a stable business environment, or by differentiators competing in a highly uncertain environment. Moreover, Fiss finds that no configuration of strategy archetype, firm structure, and environment explains the absence of very high firm performance. In our sample, the collaborations are either research collaborations or collaborations for setting up university spin-offs. When we identify configurations of explanatory conditions conducive to 'Research collaborations', we do not expect that the inverse of these configurations of explanatory conditions would then support the absence of 'Research collaborations' relationships. Indeed, we see that distinctive features emerge to explain spin-off collaborations. This is a major difference between regression analysis and fsQCA.

[9] At the survey piloting stage, academics were asked to classify the above items into 'combination', 'internalisation', and 'expert direction' based on Nonaka (1994) and Grant's (1996) definitions. The classification result is entirely consistent among the piloted academics.

[10] We used this binary measure to keep the qualitative information about access to 'gatekeepers' and repeat collaborations explicit because these elements were constantly mentioned in the pilot testing stage with academics for the collaboration formation. Furthermore, the fsQCA allows for qualitative coding and we tested analysis results using different coding scheme and calibration thresholds for the measure. The results are consistent. This variation in survey responses also helps to mitigate common methods bias in survey research (Podsakoff et al., 2003).

3.8. Calibration

The fsQCA analysis involves calibration to transform measures of a construct into fuzzy-set membership scores. The criteria used for calibration are based on theoretical or empirical knowledge (Ragin, 2008). This knowledge guides what states are considered to be in full membership of a set, in full non-membership, and in a 'cross-over' point, reflecting the most ambiguous state of membership. We explain below the criteria to set up qualitative membership thresholds.

Outcome measures and explanatory conditions were constructed based on three types of responses. In the first type of response, used to construct explanatory conditions 'Trust', 'Shared language' and 'Contract', respondents were asked to score from 1 (strongly disagree) to 5 (strongly agree) their agreement with the various statements about their collaborations with the firms. We followed similar practices in the fsQCA literature and calibrated these three measures by assigning the value of 4 (agree) as the threshold for full membership; 3 (scale midpoint; neither agree nor disagree) as the cross-over point; and 2 (disagree) as the threshold for full non-membership (Ordanini et al., 2014). In the second type of response, used to construct the outcome measures 'Knowledge transfer through research collaborations' and 'Knowledge transfer through spin-offs', respondents were asked to score from 1 (never used) to 5 (widely used) the extent to which they used the various mechanisms to absorb knowledge. For both measures, an increase in the score indicates an increase in the frequency of the use of the mechanisms. As such, we used the closest 75th, 50th and 25th percentiles as the fully in, cross-over and fully out membership thresholds (Park et al., 2020; Ragin, 2008). We calibrated by assigning the value of 3.25, 2.75, 1.75 for 'Knowledge transfer through research collaborations', and the value of 3, 2, 1 for 'Knowledge transfer through spin-offs' as the threshold for full membership, cross-over point, and full non-membership, respectively. Finally, the measures 'Research collaborations', 'Spin-offs', and 'Network' were constructed based on dichotomous responses (yes = 1 and no = 0). In these cases, a 'crisp' set approach was applied because full membership and full non-membership are directly distinguishable.

We then calibrated the data using a direct approach based on the transformation of membership scores using the metrics of log odds implemented in the fsQCA 3.0 software programme.[11] After calibration, the original scores of the constructs were transformed into values between 0 and 1, to indicate non-membership and membership, respectively. Fuzzy scores between 0.5 and 1 indicate cases that can be regarded as in the membership, and scores between 0 and 0.5 indicate cases that can be regarded as out of the membership. A fuzzy score of 0.5 indicates that the case is neither in nor out of the membership.

4. Findings

4.1. fsQCA results

Table 2 shows the details of the measures, the descriptive statistics, and the fuzzy set calibration. Table 3 shows the correlations. We performed a necessity analysis. Results show that no single explanatory condition on its own is essential for the development of different collaborations between universities and firms or for the different knowledge conversion mechanisms (Appendix C). We then conducted a sufficiency analysis, exploring whether any combination of explanatory conditions may be considered sufficient for supporting the development of the various collaborations for innovation.[12] Each configuration of explanatory conditions and its consistency score in relation to the outcome can be examined in a truth table resulting from the fsQCA analysis. For each combination of explanatory conditions in the truth table, a raw consistency score of at least 0.8 is considered acceptable for the combination to be retained in the analysis (Fiss, 2011; Ragin, 2008).[13] Any combination of explanatory conditions with a proportional reduction in consistency (PRI) score of less than 0.7 should be eliminated from the analysis (Greckhamer et al., 2018).[14] We followed these rules for all analyses. We employed a frequency cut-off of 2 for all analyses, and the threshold retained at least 80% of the cases (Greckhamer et al., 2018).

Table 4 shows the sufficiency analysis results.[15] We follow the fsQCA literature to interpret configurational relationships of the explanatory conditions (Fiss, 2011; Speldekamp et al., 2020) and the comparison across configurations (Greckhamer, 2016; Misangyi et al., 2017; Park and Mithas, 2020; Park et al., 2020; Speldekamp et al., 2020). We distinguish the core conditions, suggesting evidence of a strong causal relationship with the outcomes, provided by the parsimonious solutions (Fiss, 2011).[16] We do not apply any strict directional assumptions linking explanatory conditions and outcomes (i.e., any 'easy counterfactuals') to be used as simplifying assumptions.[17] We thus show the results of complex solutions, and single out the core conditions for interpretation. Conditions not identified as core are considered peripheral, indicating evidence of their weaker causal relationships with the outcomes (Fiss, 2011). In each configuration in Table 4, ⬤ denotes the presence of core conditions and ⊗ denotes the absence of core conditions. Smaller circles ● and ⊗ denote the presence and absence of peripheral conditions, respectively. We summarise the fsQCA findings below.

Three alternative pathways – 1a, 1b and 1c in Table 4 – are considered sufficient to support research collaborations. Overall, we see the influence of shared technical language (core or peripheral) on research

[11] Details of calculation with the fsQCA 3.0 software are available online at http://www.socsci.uci.edu/~cragin/fsQCA/software.shtml.

[12] When a combination of explanatory conditions is consistently a subset of an outcome, i.e., when all cases with the specific configuration exhibit the outcome, the combination of explanatory conditions (pathway) is regarded as a solution to the outcome, with sufficiency (Ragin, 2008). That is, a combination of explanatory conditions is sufficient if it can produce a certain outcome.

[13] If there are k explanatory conditions, a truth table with 2^k rows, i.e., 2^k combinations of explanatory conditions, will be produced. Each combination of explanatory conditions produces a raw consistency score. The raw consistency score measures the extent to which the combination is consistently a subset of the outcome (Ragin, 2008).

[14] PRI scores indicate the possibility of the simultaneous subset relations of configurations uncovered in the analysis in both the presence and the absence of the outcome. A configuration with the PRI score below 0.5 would suggest significant inconsistency (the configuration is sufficient in both the presence and the absence of the outcome).

[15] The simplified truth tables are analysed using the Quine-McCliskey algorithm. The procedure is implemented in faQCA 3.0 software. When 'Research collaborations' and 'Spin-offs'were used as outcome measures, the full sample (58 cases) was included in the analysis. When 'Knowledge transfer through research collaborations' or 'Knowledge transfer through spin-offs' were used as outcome measures, research collaborations and spin-offs were used for the analysis, respectively (29 cases for each).

[16] Parsimonious solutions assume that each of the logical remainders, i.e., the possible combinations of explanatory conditions not observed in the sample, can have either a positive or a negative outcome, depending on whether being positive or negative helps to reach the more reduced form of configurational solutions (Fiss, 2011).

[17] Therefore, the intermediate solutions provided by the fsQCA 3.0 software programme are identical to the complex solutions, where no assumptions about logical remainders are made.

Table 2
Measures, descriptive statistics, and fuzzy set calibration.

Measure	Type	Construct descriptions	Mean	Std. Dev.	Min	Max	Fuzzy set calibration		
							Fully in	Cross-over	Fully out
Outcome measure									
Research collaborations	Dummy	Whether the collaboration between the firm and university involves scientific research collaborations in EPSRC projects (yes = 1; no = 0).	0.50	0.50	0.00	1.00	1		0
Spin-offs	Dummy	Whether the collaboration between the firm and university involves setting up an academic spin-off (yes = 1; no = 0).	0.50	0.50	0.00	1.00	1		0
Knowledge transfer through research collaborations	Index Cronbach's alpha = 0.676; CR = 0.731; AVE = 0.435.	The extent to which the academic and the firm used each of the following activities to capture, interpret, and integrate knowledge created in the collaboration (1 = never used; 5 = widely used): • Regular formal reports and memos that summarise the knowledge exchanged; • Information-sharing meetings; • Face-to-face discussion by both parties; • Placement of project researchers in the company.	2.71	0.98	1.00	5.00	3.25	2.75	1.75
Knowledge transfer through spin-offs	Continuous	The extent to which the academic and the firm used consultants or technical experts to synthesise knowledge to capture, interpret, and integrate knowledge created in the collaboration (1 = never used; 5 = widely used).	2.26	1.48	1.00	5.00	3	2	1
Explanatory condition									
Shared language	Index Cronbach's alpha = 0.813; CR = 0.825; AVE = 0.716	Agreement about the nature of the collaboration between the academic and the firm (1 = strongly disagree; 5 = strongly agree): • We used a similar technical language; • We shared a common expertise.	3.22	1.24	1.00	5.00	4	3	2
Network	Dummy	The academic: 1) had worked with the firm previously on other projects; or 2) had a professional relationship with project leaders/gatekeepers in the firm prior to the collaboration (yes to any = 1; no to both = 0).	0.57	0.50	0.00	1.00	1		0
Trust	Index Cronbach's alpha = 0.812; CR = 0.824; AVE = 0.701	Agreement about the nature of the collaboration between the academic and the firm (1 = strongly disagree; 5 = strongly agree): • We were equally willing to put effort into something that we ask each other to do; • We were equally willing to share technical information with each other.	3.74	1.20	1.00	5.00	4	3	2
Contract	Index Cronbach's alpha = 0.902; CR = 0.911; AVE = 0. 838	Agreement about the nature of the collaboration between the academic and the firm (1 = strongly disagree; 5 = strongly agree): • The behaviour of both parties in this relationship was governed by a written contract; • The contract with this company stated precisely the activities to be performed in this relationship.	3.06	1.50	1.00	5.00	4	3	2

collaborations, but shared language alone is neither necessary nor sufficient. The pathways have an overall solution consistency of 0.90 and a non-trivial overall solution coverage of 0.50.[18] When the presence of shared language is core to support research collaborations (pathways 1a and 1b), either trust is absent and other conditions are peripheral (1a), or network and formal contracts are absent and trust is peripheral (1b). In these pathways, (combinations of different dimensions of) relational governance alone is conducive to research collaborations. Formal contracts are absent. Alternatively, pathway 1c shows that research collaborations can also be supported by a combination of networks and formal contracts as core conditions although shared language and trust are peripheral. This pathway is the most prevalent with a higher raw coverage of 0.33.

Only one configuration (pathway 2 in Table 4) was identified as sufficient for the development of collaborations for setting up spin-offs. Formal contracts, and the absence of shared language and network, are core to these collaborations. Trust is peripheral. The pathway has a high consistency score of 0.93. The overall solution coverage, however, is relatively low (0.14), indicating we may have captured a limited part of the complexity of the collaboration dynamics. Nonetheless, this pathway shows the central role of formal contracts in the relationships, supported by the presence of trust.

[18] The sufficiency analysis shown in Table 4 reports several indicators. The raw coverage score indicates the proportion in the membership of a given outcome explained by a configuration of explanatory conditions. The unique coverage score shows the proportion in the membership of a given outcome explained exclusively by a configuration. The consistency score measures the extent to which a single configuration is consistently a subset of a given outcome. The overall solution coverage measures the proportion in the membership of the outcome explained by the set of all identified configurations. Finally, the overall solution consistency score indicates the extent to which the set of all identified configurations is consistently a subset of a given outcome (Ragin, 2008).

Table 3
Correlation table.

	1	2	3	4	5	6	7	8
1. Research collaborations	1.00							
2. Spin-offs	−1.00	1.00						
3. Shared language	0.42***	−0.42***	1.00					
4. Network	0.31**	−0.31**	0.09	1.00				
5. Trust	0.16	−0.16	0.37***	−0.09	1.00			
6. Contract	−0.06	0.06	0.28**	−0.29**	0.21	1.00		
7. Knowledge transfer through research collaborations	0.49***	−0.49***	0.50***	0.26*	0.52***	0.23*	1.00	
8. Knowledge transfer through spin-offs	−0.04	0.04	0.28**	−0.15	0.24*	0.25*	0.20	1.00

*** significant at the 1% level; ** significant at the 5% level; * significant at the 10% level.

Table 4
Results for sufficiency analysis.

	Research collaborations [a] (Full sample)			Spin-offs [b] (Full sample)	Knowledge transfer through research collaborations [c] (Research collaborations only)		Knowledge transfer through spin-offs [d] (Setting up spin-offs only)
Explanatory condition	1a	1b	1c	2	3a	3b	4
Shared language	●	●	•	⊗	•	•	●
Network	•	⊗	●	⊗	●		⊗
Trust	⊗	•	•	•		•	•
Contract	⊗	⊗	●	●	⊗	●	●
Raw coverage	0.12	0.10	0.33	0.14	0.32	0.47	0.41
Unique coverage	0.07	0.10	0.28	0.14	0.16	0.32	0.41
Consistency	0.99	0.87	0.89	0.93	0.88	0.81	0.91
Number of cases	2	3	7	3	4	9	6
Overall solution coverage		0.50		0.14		0.64	0.41
Overall solution consistency		0.90		0.93		0.83	0.91

Note: ● = core condition, present; ⊗ = core condition, absent; • = peripheral condition, present; ⊗ = peripheral condition, absent; blank space = the explanatory condition may be present or absent.
[a] Thresholds for 'Research collaborations' as the outcome measure: frequency = 2 (100% of cases); consistency = 0.89; RPI consistency = 0.89.
[b] Thresholds for 'Spin-offs' as the outcome measure: frequency = 2 (88% of cases); consistency = 0.92; RPI consistency = 0.92.
[c] Thresholds for 'Knowledge transfer through research collaborations' as the outcome measure: frequency = 2 (89% of cases); consistency = 0.81; RPI consistency = 0.78.
[d] Thresholds for 'Knowledge transfer through spin-offs' as the outcome measure: frequency = 2 (82% of cases); consistency = 0.90; RPI consistency = 0.89.

Pathways 3a and 3b in Table 4 show the configurations that are conducive to efforts of knowledge transfer in research collaborations.[19] They exhibit a high overall solution consistency score of 0.83 and cover 64% of the membership of the outcome. Pathway 3a suggests that network, when the presence of shared language and the absence of formal contracts are peripheral, is core to the conversion of the largely explicit knowledge in research collaborations. Alternatively, pathway 3b (the more prevalent pathway with a raw coverage of 0.47) shows that formal contracts, supported by shared language and trust as peripheral conditions, are core to the conversion of the largely explicit knowledge in such collaborations. The results show that relational governance alone can facilitate deliberate efforts of knowledge conversion in research collaborations. Alternatively, relational governance together with formal contracts can also facilitate this, but the influence of relational governance is peripheral.

Pathway 4 in Table 4 illustrates the configuration of conditions that support the conversion of tacit knowledge into explicit knowledge in collaborations for setting up spin-offs.[20] While confirming the continued core role of formal contracts not only in supporting such collaborations but also in knowledge conversion, the results also show the combined core role of formal contracts together with shared knowledge for the transfer of tacit knowledge. Networks are absent and trust is peripheral. This configuration has an overall solution consistency score of 0.91 and

[19] We checked the conditions leading to the lack of efforts of knowledge transfer in research collaborations. Only one configuration identified (solution consistency is 0.84 and solution coverage is 0.30). A simultaneous lack of network and formal contracts plays a central role in the lack of efforts of knowledge transfer in the collaborations. The simultaneous presence of shared language and trust is peripheral.

[20] We checked the conditions leading to the lack of efforts of knowledge transfer in spin-offs. Two configurations are identified (solution consistency is 0.87 and solution coverage is 0.47). Only formal contracts without shared technical language (when the absence of network and the presence of trust are peripheral) are key to the lack of knowledge transfer. A presence of network without shared language and trust (and formal contracts are peripheral) also plays a key role leading to the lack of knowledge transfer in the collaborations.

Table 5
Representative quotes.

Support for Research Collaborations	
Interactions in Research Collaborations	
Shared technical language is core. Absence of trust or network and formal contracts.	"Both parties were on the same wavelength of technical understanding, in which the firm brought in a much more practical experience scale." (RC2) "[Met the collaborator] at a conference and shared the same interests for research." (RC2)
A combination of network and formal contract is core to compensate for a weak influence of knowledge relatedness.	"Usually industry partners approach me for collaboration because of my reputation and expertise in my research field." (RC3) "EPSRC-funded projects don't solve an industry problem (because the generated IP should stay in academia), they inform industry. If the purpose of academic research is to address an industry problem/question, then the projects will and should also be funded by the industry partners, to develop IP for them" (RC3) "One of the technology lead partners from industry initiated the project … I already had an existing relation with that lead industry partner before this project, through another Innovate UK project … I have already collaborated with a few beforehand, as well as established personal relationships with some key people there." (RC5) "Looking at IP generation, it was always a negotiation point between academics and industry." (RC5)
Knowledge Transfer through Research Collaborations	
Either network or formal contracts is core to foster the knowledge transfer.	"In terms of success determinants for the collaboration, the personal interaction, mainly with the PhD student for progressing the projects, but also the support of the contact person in the company." (RC2) "The PhD student in that company was closely supervised by the academic with meetings every six weeks for progress discussion of the data algorithm. The knowledge was openly shared and the academics were able to use the IP for academic purposes. Knowledge sharing was only restricted by some company's confidential data but it didn't affect the work." (RC2) "I tend to build long-term relationships with these companies. These usually start with a number of small-scale activities (related to the processes of business development) … allowing to do potentially bigger follow-on projects … not just a one-to-one relationship, but for example, within the innovation group in the business." (RC4) "Even though you have the right people in big companies, it can still be hard to work with this company due to the organisational set-up, the hierarchy, regulations and different objectives/priorities." (RC6) "For [large] companies it is not enough that 'things might happen', it is important that they can justify the collaboration by the benefits it will bring to them." (RC6)
Support for Setting Up Spin-Offs	
Interactions in Spin-Offs	
Formal contracts are core. Absence of shared technical language.	"There was no collaboration on the development side, it was more a transactional relationship." (SO3)
Knowledge Transfer through Spin-Offs	
A combination of formal contracts and shared technical language is core to facilitate the knowledge transfer. Absence of network.	"The collaborating party brought in advice on the product accreditation process … The collaboration was based on contracted research-activities for manufacturing the medical device with respect to industry standards." (SO2) "The shared technical understanding was very high from the very beginning and helpful for the collaboration." (SO2) "But the initial collaboration was sparked through personal recommendations from people in the university." (SO2) "A big aspect was the agreement on risk sharing due to small quantities … Regarding IP, they [in the spin-off] were quite cautious and didn't want IP to be created in this collaboration … They did not allow the supplier to integrate any existing IP to the manufacturing process of [the spin-off's] product … the establishment of realistic expectations of the collaboration by both parties [is important], and that any changes need to be communicated to align commercial business goals." (SO3) "[The spin-off] developed quite early on a close relationship with a small supplier in the Netherlands. The aim of the collaboration was to adapt [the spin-off's] prototypes … From the start, the relationship was heavily technical due to the technically challenging nature of the product." (SO3) "[The spin-off] did a comprehensive search and ideally wanted to collaborate with a UK company … but the range of potential firm in the UK was limited or didn't fit … Hence, [the spin-off] expanded the search to the EU." (SO3) "It is an arm's-length relationship in which the collaborating party set us on the 'right footing', things that needed to be done professionally." (SO4) "The law firm 'took [the spin-off] by hand' … The professional relationship between both parties was very open, and the law firm understood well what the needs and the wants were of the spin-off. The law firm was very professional in translating the 'knowledge' into a light/understandable document for them." (SO4) "The collaboration was established by word-of-mouth." (SO4)

a nontrivial score of 0.41 for overall solution coverage. We can see that in the spin-off relationships, relational governance together with formal contracts support effort of knowledge transfer in the collaborations, and networks are absent.

4.2. fsQCA robustness check

We carried out the recommended robustness tests for the sufficiency analysis (Greckhamer et al., 2018). Solutions obtained from fsQCA can be sensitive to the calibration criteria used. We used a stricter calibration threshold for full membership for explanatory conditions ('Trust', 'Shared language', and 'Contract') and outcome measures ('Knowledge transfer through research collaborations' and 'Knowledge transfer through spin-offs') measured with 5-point Likert-type scales. We re-calibrated the explanatory conditions by assigning the value of 5 (strongly agree) (instead of 4 in the main analysis) as the threshold for full membership; 3 (scale midpoint; neither agree nor disagree) (the same as in the main analysis) as the cross-over point; and 1 (strongly disagree) (instead of 2 in the main analysis) as the threshold for full non-membership. We re-calibrated the outcome measures by assigning the value of 4 (moderately to widely used) (instead of 3.25 for 'Knowledge transfer through research collaborations' and 3 for 'Knowledge transfer through spin-offs' in the main analysis) as the threshold for full membership; 2 (some use) (instead of 2.75 for

'Knowledge transfer through research collaborations' and same for 'Knowledge transfer through spin-offs' as in the main analysis) as the cross-over point; and 1 (never used) (instead of 1.75 for 'Knowledge transfer through research collaborations' and same for 'Knowledge transfer through spin-offs') as the threshold for full non-membership. The test results are consistent with the main analysis (Appendix Table D1). We further conducted robustness tests by altering the minimum raw consistency threshold in the truth table (Crilly, 2011). We reduced the threshold to 0.75. We further increased the frequency cut-off threshold to 3. The test results again are consistent. We checked the mean scores for 'Knowledge transfer through research collaborations' and 'Knowledge transfer through spin-offs' between research collaborations and setting up spin-offs guided by the combinations of core conditions uncovered in the main analysis. Results are in line with what we theorised (Appendix Table E1).

4.3. Supplementary case-level insights from interviews

We followed the fsQCA best practices and returned to case-level analysis representing configurations linked to the outcome of interest for a richer understanding of the identified configurations (Campbell et al., 2016; Greckhamer et al., 2018). We carried out 15 interviews with academics who responded to the survey. Six of these interviewees were involved in research collaborations (labelled RC 1–6 in the text), and nine were involved in spin-offs (labelled SO 1–9) (Appendix Table F1). Interviewees were asked semi-structured questions on the nature, start and development of the collaboration and how different factors contributed to the success or otherwise of the collaboration. Interviews lasted from 45 to 60 min and were recorded and transcribed.[21] We analysed the data to capture the behaviour of the respondents in their context and discuss how and why these knowledge flows and transfer took place. The interview data is vital in interpreting our fsQCA results (see Speldekamp et al., 2020). We present below the findings explaining the identified fsQCA configurations. We supplement our findings with case-level supporting quotes in Table 5.

4.3.1. Multiple pathways conducive to research collaborations

The fsQCA results show that shared technical language is a core condition conducive to upstream research collaborations, with network or trust as peripheral conditions (1a and 1b in Table 4). Alternatively, formal contracts are complementary with all relational governance mechanisms investigated (shared language, trust and network) as conditions conducive to upstream research collaborations (1c in Table 4). While it is not surprising that absorptive capacity of firms (Cohen and Levinthal, 1990) plays an important role in research collaborations, our analysis suggests that research collaborations can rely mostly on a high level of knowledge relatedness without critical support from trust or social ties, or the need for formal contracts. Indeed, interviewees stressed the role of channels that build shared understanding of technical issues in supporting the collaborations, including *"colleagues that know people in the industry, …conferences …, Research Council funded meetings*, [or] *application to industrial calls."* (RC2).

Interviews also supported the alternative pathway, with prior interpersonal relationships and formal contracts acknowledged as vital to facilitate research collaborations. An interviewee described, "*collaborations are based on people in companies that I know (as opposed to just the companies). So when people move, the collaboration potentials move with the people too. This goes back 25 years when I was working on my first data science project with industry*." (RC1). Nonetheless, interviewees argued that even when there were established interpersonal relationships, conflicting goals may be present. One interviewee argued that academics are interested in "*why something happens (as opposed to solving an industrial problem)*." (RC3). Another interviewee explained that "*firms might ask for innovation that I have researched more than 5 years ago … these firms don't need research in advanced AI technologies or similar that I am looking for*." (RC4). As such, they argue that parties must agree the common goals and the problems to be solved through these collaborations, and that these should be made as specific as possible. An interviewee argued, "*all parties need to be aligned in terms of having a clear idea of research questions and the problem to be solved (it needs to be as specific as possible) … regular progress meetings in which objectives are re-aligned are critical to move forward with the research project.*" (RC5). This stresses the role of formal contracts as useful coordination mechanisms in guiding diverse participants that might otherwise have conflicting goals in highly uncertain inter-organisational collaboration for innovation that would normally suffer from tensions and contradictions (Faems et al., 2008; Mayer and Argyres, 2004; Schepker et al., 2014).

4.3.2. Contractually driven pathway to setting up spin-offs

The fsQCA results uncover the importance of formal contracts in downstream innovation process of setting up university spin-offs (pathway 2 in Table 4). The lack of a strong role of shared language, trust or networking signals that academic entrepreneurs may not generally need to cultivate long-term relations in order to develop the collaboration and engage in problem-solving with professional services firms. The university TTOs were key intermediaries and helped initiate the projects. As one interviewee stated, *"[TTOs are] crucial to get started with consultancy projects."* (SO3). Many academic entrepreneurs acknowledged the absence of interpersonal relations with professional services firms, and highlighted the value of formal contracts designed with the help of the TTO in setting specific and clear goals. One argued that *"the contractual arrangement stated everything clearly from the outset."* (SO2). Nevertheless, it is worth noting that a few serial entrepreneurs emphasised that although the relationships with consultants and professional services providers in their first spin-off were normally initiated through recommendations from colleagues or TTOs, in their subsequent ventures, the relationships were based on interpersonal relationships. One stressed that "*I now choose the companies I work with by myself (based on the network built over the years)*." (SO1).

4.3.3. A shift of conditions for knowledge transfer in research collaborations

The importance of mechanisms for the conversion of largely explicit (scientific) knowledge in upstream research collaborations (such as meetings and learning-by-doing through researcher mobility and placements) were consistently emphasised in the responses given by interviewees. For example, "*the academic-led projects usually start with a kick-off meeting with representatives from industry partners to discuss the research … depending on the projects we hold monthly or quarterly meetings …. The academic team sends a student, and sometimes a postdoc, to the industry collaborator. In some, but rare, cases, the collaborating party places a representative in the academic department.*" (RC3).

This represents a mechanism for knowledge transfer based on networking and is evident in one of the pathways conducive to knowledge transfer in research collaborations (3a in Table 4). Knowledge relatedness is a contributing, but not core condition, and it can play a role without special support from formal contracts. Academics interviewed emphasised that knowledge transfer can take place without formal contracts and based instead on what an interviewee called an informal *"supportive ecosystem in which friends of friends can help"* (RC1). In such collaborations, the placement of project researchers and students is common. Firms can assimilate the cutting-edge scientific and technical knowledge through the placement of project students and researchers, and, in turn, universities can gain a closer understanding of what companies are working on. There are also platform projects that bring together academics, industry (that provides funding or data) and the UK government to address key scientific challenges such as clean energy. "*These projects are mainly initiated by academia and the generated IP stay in academia.*" (RC3). The role of formal contracts is less critical

[21] The length of the transcript of the interviews ranges from 6 to 8 pages.

Table 6
Roles played by professional services firms in setting up university spin-offs (1 = not at all; 5 = to a great extent).

Roles of professional services firms in university spin-offs (ranked)	Mean score
Advised on IP	**3.172**
Helped to accelerate progress toward reaching milestones	**2.483**
Supported the licensing of your technology	**2.276**
Facilitated networking and peer mentoring	2.241
Advised on business strategy/management team	2.138
Acted as deal broker/maker	2.138
Offered space for social interaction	2.034
Offered affordable working space	1.897
Contributed to technological development	1.828
Provided early-stage funding	1.621
Provided multistage, benchmarked financing	1.138

here.

On the other hand, for industry-initiated projects, formal contracts were argued to be important to govern the conflicting goals of knowledge transfer in collaborative research. As argued by an interviewee, "*it was always a negotiation point … the academic's aim is to publish the IP [fast] whereas industry aims for commercial exploitation*." (RC5). This supports the alternative pathway showing that formal contracts are essential in the conversion of the largely explicit knowledge, to safeguard opportunism, with shared technical language and trust as peripheral (3b in Table 4).

4.3.4. Additional influence of shared technical language on knowledge transfer in the setting up of spin-offs

While collaborations between academics and professional services firms in the setting up of academic spin-offs are largely supported by formal contracts, with peripheral contribution from trust (and display an absence of shared language and network) (pathway 2 in Table 4), when efforts of knowledge transfer ('expert direction') are concerned, additional major contribution from shared language is essential (pathway 4 in Table 4). Although the parties in this type of collaboration may have knowledge bases corresponding to different knowledge domains, if professional services firms possess a highly developed scientific knowledge base, this would enable them to work more effectively with academics in knowledge transfer in the setting up of spin-offs.

This may be attributed to the fact that among the various types of advice provided by professional services firms, the advice on IP was the most important, according to our respondents (Table 6). Our interviews confirm that it is an advantage for professional services firms to share and understand the technical content of academics' work when they assist in the commercialisation of science. As argued by an interviewee, *"[the spin-off] learned about the supplier's capabilities (it's not like browsing in a catalogue) and the supplier learned about the key issues [involved in] the quality of the final product … the knowledge tends to sit in a small number of people and as people move around, the knowledge needs to be re-established*." (SO3). Furthermore, scientific discoveries made in the laboratory require further development for commercialisation. Academic entrepreneurs pointed out the importance of collaboration with technical consultants to obtain accreditation or to develop prototypes suitable for manufacture for the setting up of their spin-offs. Indeed, interviewees emphasised that when professional services firms shared a technical knowledge base with academics, communication between the academics and consultants was enhanced. As one interviewee argued, *"the knowledge transfer was facilitated by straightforward communication … speaking the same technical language and thus didn't need major elaboration*." (SO1).

5. Discussion and conclusions

The purpose of this study was to understand the interplay of different dimensions of relational governance and formal contracts in supporting university-industry collaborations for innovation. Our results show that when universities collaborate with firms in research collaborations, where goals and deliverables are ambiguous and uncertain, multiple pathways are conducive to the collaborations. A first pathway, where formal contracts are absent, shows shared technical language, rather than network or trust, as core condition for the collaborations. This result echoes the literature that suggests that technical competences can serve as a strong signal to attract partners for inter-organisational research collaborations (e.g., Göktepe-Hulten and Mahagaonkar, 2010), and that shared technical language plays a key role in establishing a common vehicle for communication between academics and industrial firms when they lack social ties prior to the collaboration (Al-Tabbaa and Ankrah, 2016). A second pathway suggests that weak knowledge relatedness can be compensated by formal contracts to support resources of access to the gatekeepers or prior working relationships as core conditions for the collaborations, with peripheral contribution from trust. This pathway supports the complementarity arguments documented in literature (e.g., Li et al., 2010; Poppo and Zenger, 2002; Ryall and Sampson, 2009).

When we examine the conditions conducive to knowledge transfer in research collaborations (to convert the largely explicit knowledge created in the collaborations into explicit or tacit knowledge for the benefit of firms), two pathways are identified. A first pathway shows relational governance alone (without formal contracts) as conducive to knowledge transfer in research collaborations. Here, shared technical language plays a supporting role and formal contracts are absent for knowledge transfer. Rather, network (via prior interpersonal relationships or access to gatekeepers) is core to the conversion of knowledge, along with other conditions. Indeed, there is empirical evidence of scientific communities including scientists from university and industry collaborating to address health crises without contracts. For instance, in 2016, to accelerate the process of solving the most persistent problems in neuroscience, the Montreal Neurological Institute, part of the Canadian McGill University Health Centre network, decided to fully embrace the principles of open science by sharing data and research results and eschew patent rights, regardless of whether research was done internally or externally with industry or other types of partners.[22] In this pathway, a quality network to form an open science oriented ecosystem is core to knowledge transfer. A second pathway relies on formal contracts (as core conditions) combined with relational governance mechanisms (as peripheral conditions) for knowledge transfer. This supports the argument that formal contracts can be central for knowledge transfer efforts when conflicts in goals between parties are likely (He et al., 2021) and knowledge ownership and IP is a concern (Hall et al., 2001). The collaborations often depend on the presence of fine-tuned formal contracts that meet the interests of firms while facilitating the right to publish for academics (Antonelli, 2008). We thus propose the following:

Proposition 1. *In upstream research collaboration between academics and firms for innovation, where goals and deliverables are ambiguous and uncertain, either relational governance alone without formal contracts, or relational governance together with formal contracts are conducive to the development of as well as knowledge transfer in the collaborations.*

Proposition 2. *In upstream research collaboration between academics and firms for innovation, where goals and deliverables are ambiguous and uncertain, when formal contracts are absent,* 1) *shared technical language is core and other relational governance dimensions peripheral or absent, for the development of the collaborations, and* 2) *network is core and other relational governance dimensions peripheral for knowledge transfer in the collaborations.*

In contrast, in collaborations between academics and firms to set up

[22] Montreal Neurological Institute website: https://www.mcgill.ca/neuro/(accessed on 22 Nov 2023).

academic spin-offs, where the goals and deliverables are specific and clear, we see the prevalence of formal contracts as a core condition. Although formal contracts are combined with different relational governance dimensions, these relational governance dimensions are either peripheral or absent. Our findings echo existing literature that suggests a general absence of social ties between entrepreneurial academics and industrial firms in these collaborations (Hayter, 2016; Rasmussen et al., 2015).[23] In the presence of efforts to convert expert direction in the collaborations, shared technical language emerges as a core condition for knowledge transfer in the collaborations. Thus, when firms act as intermediaries, their competence in speaking the same technical language as their clients is crucial for knowledge transfer (Albats et al., 2020). We propose the following:

Proposition 3. *In collaboration between academics and firms for downstream innovation process such as the setting up of academic spin-offs, where goals and deliverables are specific and clear, formal contracts together with relational governance are conducive to the development of as well as knowledge transfer in the collaborations.*

Proposition 4. *In collaborations between academics and firms for downstream innovation process such as the setting up of academic spin-offs, where goals and deliverables are specific and clear*, 1) *formal contracts are core for the development of the collaborations, and* 2) *shared technical language together with formal contracts are core conditions conducive to knowledge transfer in the collaborations. In both scenarios, network is absent and trust is peripheral.*

From a governance match perspective, we can see that in upstream research collaborations, when values and goals are ambiguous, multiple combinations of relational governance and formal contracts are possible. It is likely that when industrial goals (e.g., commercialisation, including the need to address IPRs) are prevalent, formal contracts as control or coordination tools co-exist with relational governance. And when academic norms (e.g., open science) are prevalent, relational governance alone can be sufficient. In contrast, in downstream academic spin-off activities, when goals are specific and clear, the influence of formal contracts prevails, and formal contracts are supported by relational governance. From a process view, we do not find a major shift in terms of the combinations of relational and formal governance from the development phase to the knowledge transfer phase. Nevertheless, the combinations of the various dimensions of relational governance vary by phases, suggesting that governance dynamics is sensitive to the different dimensions of relational governance while formal contracts have a more consistent effect. For instance, 'internalisation' by firms to convert the largely explicit knowledge to tacit knowledge in upstream research collaborations requires an environment that also nurtures deeper social interactions, so the absence of network is never a core condition when there are deliberate efforts for knowledge transfer in the collaboration. In contrast, network can be absent in the development of upstream research collaborations when there is sufficient shared expertise (e.g., pathway 1b in Table 4). In spin-off collaborations, deliberate knowledge transfer activities involve consultants' extra efforts to cultivate knowledge relatedness with academics so consultants can translate their tacit knowledge to codifiable information for entrepreneurial academics to act on.

[23] Grossetti (2008) draws on French cases and shows that social ties explain the formation of relationships between public research institutions and firms in the setting of new ventures. Scholten et al. (2015) show that social ties explain early growth of Dutch academic spin-offs. In both cases, however, the effects of social ties with external knowledge providers on academic spin-offs are not assessed explicitly.

5.1. Theoretical contributions

This study offers alternative insights that extend the literature on the governance of inter-organisational collaboration for innovation and on university-industry collaborations. Our study advances the literature on the governance of inter-organisational collaborations in terms of contextualising the key mechanisms in the dynamics of collaboration (Lumineau et al., 2023). Emerging studies highlight the importance of governance match, considering the context of different phases of collaborations from a process view (Colm et al., 2020; Howard et al., 2019; Steinmo and Rasmussen, 2018; Swärd et al., 2023; Vedel and Geraldi, 2023), of heterogeneous exchange attributes within the collaborations (Hofman et al., 2017), and of divergent roles of members involved in the collaborations (Bercovitz and Tyler, 2014). By acknowledging heterogeneity and comparing the governance supporting two contrasting types of collaborations and in different phases, we contribute to a more pluralistic perspective that explores the various paths and outcomes through which organisations actually work together towards an agreed objective (Lumineau and Barros De Oliveira, 2018). We show that when goals are ambiguous and uncertain, as in the case of upstream research collaborations, two pathways support the collaboration: first, a combination of relational governance and formal contracts, and, second, relational governance alone. In contrast, where goals are specific and clear, as in the setting up of spin-offs, contracts are key. We show also that the combinations of relational governance and formal contracts vary in terms of supporting the development and in terms of encouraging knowledge transfer in such collaborations. Our study offers new insights going beyond debates over the complementarity or substitutability of relational governance and formal contracts in supporting inter-organisational collaborations (Lumineau et al., 2023).

Moreover, our study unveils a different picture from that of Vedel and Geraldi (2023), who consider industrial managers' view on the collaborations. They show that relational governance and formal contracts coexist in university-industry research collaborations for novel drug discovery, and that their co-existence is complementary yet paradoxical in enabling industrial managers to deal with contradictory goal tensions with academia. Our study instead indicates that relational governance can sometimes stand alone in supporting the collaborations. Our study echoes that of Howard et al. (2019), who demonstrate that the functionality of governance mechanisms can be divergent and can change over time.

We also cast further light on inconclusive results in the university-industry collaboration literature. Rather than attempting to untangle how the individual dimensions of relational governance and formal contracts are conducive to the collaborations between universities and firms for innovation (Al-Tabbaa and Ankrah, 2016; Hayter, 2016; Majuri, 2022; Plewa et al., 2013; Steinmo and Rasmussen, 2018), we employ a configuration approach and the fsQCA method and uncover the multiple pathways and the conjunction of relevant conditions conducive to the collaborations. This suggests that the existing literature's inconclusive results may be explained by a lack of attention to equifinality and to the conjunction of multiple explanatory conditions of the complex phenomenon. For instance, previous studies suggest that experienced firms first build on knowledge relatedness to establish research collaborations with university and over time reinforce the collaboration through trust (Steinmo and Rasmussen, 2018). In contrast to Steinmo and Rasmussen (2018), however, we show that trust can be absent, peripheral or irrelevant in the configurations conducive to these collaborations. This, of course, could be due to interrelations between trust and both shared language and network (Tsai and Ghoshal, 1998). Nevertheless, this shows the importance of assessing the influence of all relational governance dimensions simultaneously, in conjunction with the influence of formal contracts, as we do in this study. Our findings thus show the importance of considering simultaneously the different dimensions of relational governance and formal contracts.

The existing literature's inconclusive results may further be

explained by a lack of attention to the different attributes associated with different types of university-industry collaborations and the match with governance mechanisms. We compare two polar types of collaborations characterised by varied levels of uncertainty, in which the various conditions interact with each other to influence university-industry collaborations, and show more nuanced combinations of functional governance conditions. The broader governance pattern is more similar in upstream research collaborations where the quality and intensity of the network (e.g., prior interpersonal relationships and access to gatekeepers) are conducive to the collaborations (e.g., Grossetti, 2008; Majuri, 2022; Plewa et al., 2013), but we show further the conjunctural influence of knowledge relatedness, trust and contracts in such a context. In downstream innovation collaborations, with goals such as solving specific industrial problems (Tabbaa and Ankrah, 2016) or direct commercialisation (Hayter, 2016), joint problem-solving can be supported by goodwill trust leading to mutual commitment (and highlight the influence of formal contracts as our study uncovers).

5.2. Managerial and policy implications

Our findings encourage academics, firm managers and policymakers concerned with academic engagement and commercialisation to reconsider the focus of their efforts. Much attention has been paid to measures that can enhance specific types of conditions, or best practices, as enablers of different types of collaborations and knowledge transfer and conversion mechanisms. Our results suggest that efforts should be placed instead on nourishing diverse academic engagement and commercialisation environments to develop rich configurations of conditions that can encourage both the development of collaborations and knowledge transfer in the collaborations. For instance, for a conducive research collaboration environment, knowledge relatedness may combine with a good quality network, or trust, or may be peripheral in conjunction with other relational governance dimensions and the support of contracts.

Furthermore, university-industry collaborations are promoted by policymakers and practitioners on the assumption that the formation of such collaborations leads automatically to knowledge transfer. Our research suggests that attention should also be paid to the distinction between an environment that simply helps to establish collaborations and one that also ensures knowledge transfer in the collaborations. For instance, knowledge relatedness is neither necessary nor sufficient in developing collaborations between universities and professional services firms in the setting up of academic spin-offs. Nevertheless, knowledge relatedness, combined with formal contracts and goodwill trust, is key to facilitating knowledge transfer in such collaborations. This shows the value of technical knowledge as an important competence for professional services firms (Albats et al., 2020). Making sure professional services firms develop cognitive capital related to particular universities' knowledge should help knowledge transfer, even though it may not be a critical condition for the initial development of such collaborations.

5.3. Limitations and future research

The present study sheds lights on collaborations for innovation between top universities and firms in ambitious research projects and spin-offs in the UK. Nevertheless, channels of academic engagement and commercialisation are very diverse and the actors very heterogeneous (Perkmann et al., 2011; Schartinger et al., 2002) therefore also the dynamics of knowledge transfer in such collaborations. We encourage further research to verify our propositions, comparing and contrasting the nature of the collaboration relationships by investigating simultaneously more types of collaborations for innovation between universities and firms. One possible avenue is differentiating among research collaborations – exploring knowledge flows and transfer in smaller research collaborations from those in recent type of very large experimental partnerships for frontier science between whole university departments and industry, involving much uncertainty and difficulties in defining the required output. Furthermore, knowledge transfer may occur well after the collaboration period, in terms of joint efforts towards publishing, patenting or licensing, so that knowledge conversion may happen after the collaboration period as we discussed here. Further research could investigate in more detail the casual dynamics behind the configurations we observed. Larger sized and longitudinal data and analyses could confirm whether the configurations we posed are truly casual and how they come about.

We explored the collaboration dynamics through empirical data collected only from academics to shed light on how academics work with industry for innovation. Nevertheless, following Kale et al. (2000), we carefully adopted constructs that reflect dyadic relationships. For instance, the construct 'Trust' was based on academics' assessment of the extent to which the academics and the firms were 'equally willing to put effort into something that we ask each other to do' and were 'equally willing to share technical information with each other'. Nonetheless, it would be beneficial for future work to develop the key constructs through the assessment of the attributes supporting the relationships from the perspectives of all parties. It would also be beneficial to adopt a more pluralistic perspective to assess the perceived functionality of governance from the perspectives of both university and industry.

Moreover, we addressed our research question through the lens of collaboration for innovation between universities and professional services firms. While existing literature indicates that professional services firms, like high-tech manufacturing firms, seek knowledge from universities for breakthrough innovations (Audretsch and Belitski, 2019; Lee and Miozzo, 2019), future research may explore whether the interplay between relational governance and formal contracts in inter-organisational collaborations differs by sector or industry. Finally, further research can explore whether the multiple pathways involving varying patterns of combinations of knowledge relatedness, network or formal contracts as core conditions is intertwined with the nature of the development of specific collaboration/project types, or of the development of an individual academic's research collaboration relationship with a specific firm, or the results of academics' self-selection to utilise their unique strengths for the collaborations.

CRediT authorship contribution statement

Hsing-fen Lee: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Marcela Miozzo:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Data availability

The authors do not have permission to share data.

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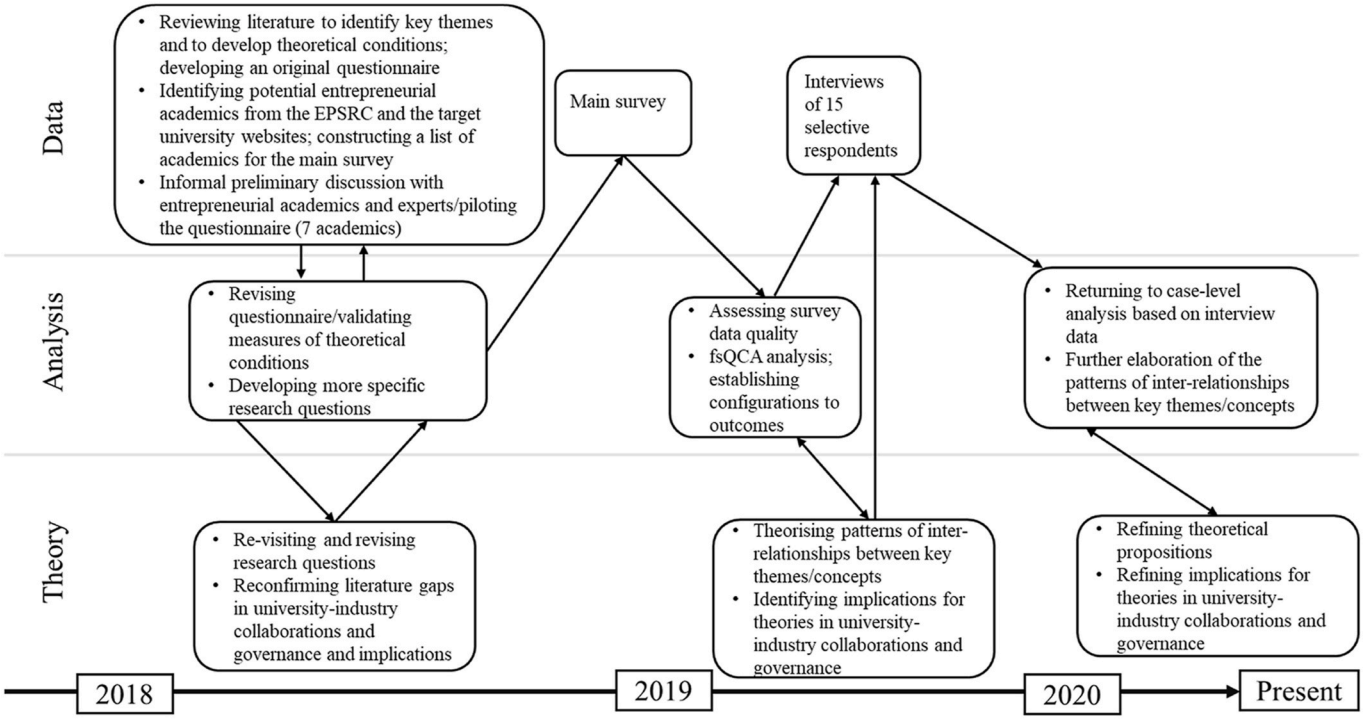
Appendix A

Appendix Table A1
Demographic information of survey respondents (N = 53)

Respondent demographic information	Distribution (%)
Type of collaboration involved in	
Research collaboration	55%
Setting up spin-offs	45%
Rank	
Full professor	62%
Associate or assistant professor (Reader, senior lecturer or lecturer)	38%
Gender	
Male	91%
Female	9%
Discipline	
Engineering (including computer sciences)	68%
Sciences (including medical sciences)	32%

Appendix B



Appendix Fig. B1. Research process map.

Appendix C. Necessity analysis

A necessity analysis investigates whether any of the conditions may be considered a necessary condition by itself, first, for research collaborations or setting up spin-offs, and second, for the knowledge transfer and conversion in the two types of collaborations. An explanatory condition is considered necessary when an outcome cannot occur without that condition (Ragin, 2008). In theory, it means that the presence of the outcome is always in agreement with the presence of the explanatory condition (that is, the outcome is a subset of the explanatory condition) (Ragin, 2008). The consistency score in a necessity analysis measures the extent of agreement, where a score of 1 indicates full agreement. Existing literature suggests that when the consistency score of an explanatory condition in a necessity analysis is 0.9 or above, the condition is almost always necessary for the outcome (Schneider et al., 2010). A necessity analysis also produces a coverage score for each explanatory condition. A coverage score measures whether the condition is trivial or non-trivial. A coverage score close to 0 suggests that the condition is trivial. Therefore, an explanatory condition could be necessary but theoretically and empirically trivial. This is the case when, for example, an explanatory condition is always present in all cases, independent of whether the outcome is present or absent. Schneider et al. (2010) provide detailed insights for such analyses. The results of the necessity analysis (Table C1) show that there is no type of explanatory condition that, in isolation, is necessary for any of the outcomes. In other words, neither a single type of relational governance dimension nor having formal contracts on its own is essential to account for the different collaborations between universities and firms for the different knowledge conversion mechanisms. This confirms the suitability of assessing the influence of the interplay

between the relational governance dimensions and formal contracts for interactions and knowledge transfer in different collaborations between universities and firms.

Appendix Table C1
Necessity analysis

	Research collaborations (Full sample)		Spin-offs (Full sample)		Knowledge transfer through research collaborations (Research collaborations only)		Knowledge transfer through spin-offs (Setting up spin-offs only)	
	Consistency	Coverage	Consistency	Coverage	Consistency	Coverage	Consistency	Coverage
Shared language	0.77	0.63	0.45	0.37	0.79	0.89	0.72	0.75
Network	0.72	0.64	0.41	0.36	0.75	0.90	0.35	0.40
Trust	0.81	0.55	0.67	0.45	0.82	0.89	0.84	0.59
Contract	0.50	0.48	0.55	0.52	0.53	0.92	0.72	0.62

Appendix Table D1
Results for sufficiency analysis with re-calibrated membership thresholds.

	Research collaborations [a] (Full sample)		Spin-offs [b] (Full sample)	Knowledge transfer through research collaborations [c] (Research collaborations only)		Knowledge transfer through spin-offs [d] (Setting up spin-offs only)
Explanatory condition	1a	1b	2	3a	3b	4
Shared language	●	•	⊗	•	•	●
Network	•	●	⊗	●		⊗
Trust	⊗	•	•		•	•
Contract	⊗	●	●	⊗	●	●
Raw coverage	0.17	0.33	0.17	0.37	0.51	0.40
Unique coverage	0.06	0.22	0.17	0.14	0.28	0.40
Consistency	0.86	0.84	0.81	1.00	0.94	0.84
Number of cases	2	7	3	4	9	6
Overall solution coverage	0.50		0.17	0.64		0.40
Overall solution consistency	0.90		0.81	0.95		0.84

Note: ● = core condition, present; ⊗ = core condition, absent; • = peripheral condition, present; ⊗ = peripheral condition, absent; blank space = the explanatory condition may be present or absent.
[a] Thresholds for 'Research collaborations' as the outcome measure: frequency = 2 (88% of cases); consistency = 0.84; RPI consistency = 0.84.
[b] Thresholds for 'Spin-offs' as the outcome measure: frequency = 2 (88% of cases); consistency = 0.81; RPI consistency = 0.81.
[c] Thresholds for 'Knowledge transfer through research collaborations' as the outcome measure: frequency = 2 (89% of cases); consistency = 0.93; RPI consistency = 0.90.
[d] Thresholds for 'Knowledge transfer through spin-offs' as the outcome measure: frequency = 2 (82% of cases); consistency = 0.84; RPI consistency = 0.80.

Appendix Table E1
Comparing mean scores of 'Knowledge transfer through research collaborations' and 'Knowledge transfer through spin-offs' between the research collaboration and the spin-off relationships

	Research collaboration relationships	Spin-off relationships	p value
Knowledge transfer through research collaborations, when "Network" has a full membership	3.32	2.23	0.00
Knowledge transfer through research collaborations, when "Contract" has a full membership	3.30	2.50	0.04
Knowledge transfer through spin-offs, when "Shared language" has a full membership	2.09	3.23	0.03

Appendix Table F1
Interview data description

Type of collaborations	University academic field	Key industrial firm(s)	Nature of the collaboration
Research collaboration	Computer Science (RC1)	A range of large financial services, retail, health care services firms.	• Firms (e.g., Goldman Sachs, Deutsche Bank, etc.) approached the academic for specific expertise and used universities as "innovation resources", often featured with placement of project researchers to work on the projects in firms, for projects in areas such as data forecasting modelling. • The academic benefits from the research collaborations with the firms, labelled as a "relationship ecosystem", via inputs and resources from high-profile firms.
Research collaboration	Engineering (RC2)	Technology services firm	• Through the access to the gatekeeper in firm, the collaboration was established to develop a new modelling method that the firm might apply in industry.
Research collaboration	Engineering (RC3)	A range of firms (engineering/technical services and manufacturing firms) in the energy sector	• The project brought together academics, industrial partners and the UK government to address key challenges such as "why something happens" facing the energy sector.
Research collaboration	Computer Science (RC4)	A range of firms including financial services, retail, media services firms.	• Research into the application of advanced artificial intelligence to capture and analyse human data.
Research collaboration	Mechanical Engineering (RC5)	Firms in the hydrogen and fuel cell technology sector	• Feasibility study to experiment and develop new methodologies potentially for industrial application.
Research collaboration	Computer Science (RC6)	A range of firms including financial services, retail, media services firms.	• The project brought together academics, industrial partners, public sector and the non-profit sector to address a wide spectrum of subjects that will impact the digital economy of tomorrow.
Spin-off (a product company)	Physic (SO1)	Technical consultancy firm	• A PhD – led spin-off. Highly academic protype unsuitable for industry. As such inputs from the technical consultancy firms were sought to develop a prototype suitable for manufacturing.
Spin-off (a product company)	Biomedical Engineering (SO2)	Patent agents Technical consultancy firm	• The spin-off needed the entire ownership of IPs and know-how for its innovative product (a new medical device). • The spin-off needed advice on the product accreditation process and overall quality control over the production process.
Spin-off (a consultancy firm)	Electrical and Electric Engineering (SO3)	Network facilitator/platform Technical consultancy firm	• Contract research and consultancy as main business to generate income to grow. • The network facilitator/platform enabled the spin-off to secure one-off consultancy jobs form a wide range of clients. • Technical consultancy firm helped with prototyping
Spin-off (a consultancy firm)	Chemical Engineering (SO4)	Law firm Accountancy firm	• The law firm was helpful in "taking the spin-off by hand" and guild the new venture through the business procedures that needed to be done, such as employment contracts, licensing contracts, patenting issues, etc.
Spin-off (a product company)	Neuroscience (SO5)	A product development firm (a game app development firm)	• The spin-off generated an innovative idea of integrating cognitive neuroscience for a intervention game play app for children and adults. The product development firm helped to realise the product idea.
Spin-off (a product company)	Neuroscience (SO6)	Law firm/patent agent Accountancy firm	• The spin-off developed all necessary technologies (IT research and development) in-house for its product (medical imaging). The professional services firms helped with commercialisation.
Spin-off (a product company)	Data science/software engineering (SO7)	Law firm/patent agent Venture capitalist	• The patent agent assisted to licensing out the university owned patent to the spin-off. • The venture capitalist joined the Board with some shares and offered valuable strategic and business advice.
Spin-off (a product company)	Chemistry (SO8)	Main connections all through university TTO (no specific firms identified)	• The university TTO functioned as a one-stop shop connecting the spin-off with professional services in all areas (patent application, job advertisement, board meeting facilitation, access to funding, etc.).
Spin-off (a product company)	Neurology (SO9)	Main connections all through university TTO (no specific firms identified)	• The university TTO functioned as a one-stop shop connecting the spin-off with professional services in all areas (patent application, access to funding, appointment of an experienced CEO, etc.) for the commercialisation of a new compound.

References

Al-Tabbaa, O., Ankrah, S., 2016. Social capital to facilitate 'engineered' university–industry collaboration for technology transfer: a dynamic perspective. Technol. Forecast. Soc. Change 104, 1–15.

Albats, E., Bogers, M., Podmetina, D., 2020. Companies' human capital for university partnerships: a micro-foundational perspective. Technol. Forecast. Soc. Change 157, 120085.

Alvarez, S.A., Barney, J.B., 2001. How entrepreneurial firms can benefit from alliances with large partners. Acad. Manag. Exec. 15 (1), 139–148.

Antonelli, C., 2008. The new economics of the university: a knowledge governance approach. J. Technol. Tran. 33, 1–22.

Audretsch, D.B., Belitski, M., 2019. The limits to collaboration across four of the most innovative UK industries. Br. J. Manag. 31, 830–855.

Bercovitz, J., Tyler, B.B., 2014. Who I am and how I contract: the effect of contractors' roles on the evolution of contract structure in university–industry research agreements. Organ. Sci. 25, 1840–1859.

Blomqvist, K., Hurmelinna, P., Seppänen, R., 2005. Playing the collaboration game right—balancing trust and contracting. Technovation 25, 497–504.

Bruneel, J., D'Este, P., Salter, A., 2010. Investigating the factors that diminish the barriers to university–industry collaboration. Res. Pol. 39, 858–868.

Campbell, J.T., Sirmon, D.G., Schijven, M., 2016. Fuzzy logic and the market: a configurational approach to investor perceptions of acquisition announcements. Acad. Manag. J. 59 (1), 163–187.

Carson, S.J., Madhok, A., Tao, W., 2006. Uncertainty, opportunism, and governance: the effects of volatility and ambiguity on formal and relational contracting. Acad. Manag. J. 49 (5), 1058–1077.

Chua, C.E.H., Lim, W.K., Soh, C., Sia, S.K., 2012. Enacting clan control in complex IT projects: a social capital perspective. MIS Q. 36 (2), 577–600.

Chung, H.F.L., Wang, C.L., Huang, P.-h., Yang, Z., 2016. Organizational capabilities and business performance: when and how does the dark side of managerial ties matter? Ind. Market. Manag. 55, 70–82.

Clarysse, B., Wright, M., Lockett, A., Mustar, P., Knockaert, M., 2007. Academic spinoffs, formal technology transfer and capital raising. Ind. Corp. Change 16, 609–640.

Clauss, T., Kesting, T., 2017. How businesses should govern knowledge-intensive collaborations with universities: an empirical investigation of university professors. Ind. Market. Manag. 62, 185–198.

Clayton, P., Feldman, M., Lowe, N., 2018. Behind the scenes: intermediary organizations that facilitate science commercialization through entrepreneurship. Acad. Manag. Perspect. 32 (1), 104–124.
Cohen, W.M., Levinthal, D.A., 1990. Absorptive capacity: a new perspective on learning and innovation. Adm. Sci. Q. 35 (1), 128–152.
Colm, L., Ordanini, A., Bornemann, T., 2020. Dynamic governance matching in solution development. J. Market. 84 (1), 105–124.
Crilly, D., 2011. Predicting stakeholder orientation in the multinational enterprise: a mid-range theory. J. Int. Bus. Stud. 42, 694–717.
Dasgupta, P., David, P.A., 1994. Toward a new economics of science. Res. Pol. 23 (5), 487–521.
Davids, M., Frenken, K., 2018. Proximity, knowledge base and the innovation process: towards an integrated framework. Reg. Stud. 52 (1), 23–34.
De Luca, L.M., Atuahene-Gima, K., 2007. Market knowledge dimensions and cross-functional collaboration: examining the different routes to product innovation performance. J. Market. 71 (1), 95–112.
De Reuver, M., Bouwman, H., 2012. Governance mechanisms for mobile service innovation in value networks. J. Bus. Res. 65 (3), 347–354.
Deeds, D.L., Hill, C.W.L., 1998. An examination of opportunistic action within research alliances: evidence from the biotechnology industry. J. Bus. Ventur. 14 (2), 141–163.
Dhanaraj, C., Lyles, M.A., Steensma, H.K., Tihanyi, L., 2004. Managing tacit and explicit knowledge transfer in IJVs: the role of relational embeddedness and the impact on performance. J. Int. Bus. Stud. 35, 428–442.
D'Este, P., Guy, F., Iammarino, S., 2013. Shaping the formation of university-industry research collaborations: what type of proximity does really matter? J. Econ. Geogr. 13 (4), 537–558.
Eisenhardt, K.M., Graebner, M.E., 2007. Theory building from cases: opportunities and challenges. Acad. Manag. J. 50 (1), 25–32.
Faems, D., Janssens, M., Madhok, A., Van Looy, B., 2008. Toward an integrative perspective on alliance Governance: connecting contract design, trust dynamics, and contract application. Acad. Manag. J. 51 (6), 1053–1078.
Fainshmidt, S., Witt, M.A., Aguilera, R.V., Verbeke, A., 2020. The contributions of qualitative comparative analysis (QCA) to international business research. J. Int. Bus. Stud. 51, 455–466.
Fiss, P.C., 2011. Building better causal theories: a fuzzy set approach to typologies in organization research. Acad. Manag. J. 54, 393–420.
Göktepe-Hulten, D., Mahagaonkar, P., 2010. Inventing and patenting activities of scientists: in the expectation of money or reputation? The. Journal of Technological Transfer 35, 401–423.
Granovetter, M.S., 1992. Problems of explanation in economic sociology. In: Nohria, N., Eccles, E.R. (Eds.), Networks and Organizations: Structure, Form and Action. Harvard Business School Press, Boston, pp. 25–56.
Grant, R.M., 1996. Towards a knowledge-based theory of the firm. Strat. Manag. J. 17, 109–122.
Grant, R.M., Baden-Fuller, C., 2004. A knowledge accessing theory of strategic alliances. J. Manag. Stud. 41 (1), 61–84.
Greckhamer, T., 2016. CEO compensation in relation to worker compensation across countries: the configurational impact of country-level institutions. Strat. Manag. J. 37 (4), 793–815.
Greckhamer, T., Furnari, S., Fiss, P., Aguilera, R.V., 2018. Studying configurations with QCA: best practices in strategy and organization research. Strat. Organ. 16 (4), 482–495.
Grossetti, M., 2008. Proximities and embedding effects. Eur. Plann. Stud. 16 (5), 629–642.
Gulbrandsen, M., Smeby, J.C., 2005. Industry funding and university professors' research performance. Res. Pol. 34, 932–950.
Gu, F.F., Hung, K., Tse, D.K., 2008. When does Guanxi matter? Issues of capitalization and its dark sides. J. Market. 72, 12–28.
Hall, B.H., Link, A.N., Scott, J.T., 2001. Barriers inhibiting industry from partnering with universities: evidence from the Advanced Technology Program. J. Technol. Tran. 26, 87–98.
Hara, G., Kanai, T., 1994. Entrepreneurial networks across oceans to promote international strategic alliances for small businesses. J. Bus. Ventur. 9 (6), 489–507.
Hauschildt, J., Kirchmann, E., 2001. Teamwork for innovation – the 'Troika' of promotors. R D Manag. 31, 41–49.
Hayter, C.S., 2016. Constraining entrepreneurial development: a knowledge-based view of social networks among academic entrepreneurs. Res. Pol. 45, 475–490.
He, V.F., von Krogh, G., Siren, C., Gersdor, T., 2021. Asymmetries between partners and the success of university-industry research collaborations. Res. Pol. 50, 104356.
Heringa, P.W., Horlings, E., Zouwen, M.V.D., Besselaar, P.V.D., Vierssen, W.V., 2014. How do dimensions of proximity relate to the outcomes of collaboration? A survey of knowledge-intensive networks in the Dutch water sector. Econ. Innovat. N. Technol. 23 (7), 689–716.
Hite, J., 2005. Evolutionary processes and paths of relationally embedded network ties in emerging entrepreneurial firms. Enterpren. Theor. Pract. 29, 113–145.
Hofman, E., Faems, D., Schleimer, S.C., 2017. Governing collaborative new product development: toward a configurational perspective on the role of contracts. J. Prod. Innovat. Manag. 34, 739–756.
Howard, M., Roehrich, J., Lewis, M., Squire, B., 2019. Converging and diverging governance mechanisms: the role of (dys)function in long-term inter-organizational relationships. Br. J. Manag. 30, 624–644.
Huber, F., 2012. On the role and interrelationship of spatial, social and cognitive proximity: personal knowledge relationships of R&D workers in the Cambridge Information Technology Cluster. Reg. Stud. 46 (9), 1169–1182.
Kale, P., Singh, H., Perlmutter, H., 2000. Learning and protection of proprietary assets in strategic alliances: building relational capital. Strat. Manag. J. 21 (3), 217–237.
Kogut, B., Zander, U., 1996. What do firms do? Coordination, identity and learning. Organ. Sci. 7, 502–518.
Lawton Smith, H., Chapman, D., Wood, P., Barnes, T., Romeo, S., 2014. Entrepreneurial academics and regional innovation systems: the case of spin-offs from London's universities. Environ. Plann. C Govern. Pol. 32, 341–359.
Lee, H.-F., Miozzo, M., 2015. How does working on university–industry collaborative projects affect science and engineering doctorates' careers? Evidence from a UK research-based university. J. Technol. Tran. 40 (2), 293–317.
Lee, H.-F., Miozzo, M., 2019. Which types of knowledge-intensive business services firms collaborate with universities for innovation? Res. Pol. 48 (7), 1633–1646.
Li, J.J., Poppo, L., Zhou, K.Z., 2010. Relational mechanisms, formal contracts, and local knowledge acquisition by international subsidiaries. Strat. Manag. J. 31 (4), 349–370.
Li, Y., Wang, X., Huang, L., Bai, X., 2013. How does entrepreneurs' social capital hinder new business development? A relational embeddedness perspective. J. Bus. Res. 66, 2418–2424.
Lin, N., 2001. Social Capital: A Theory of Social Structure and Action. Cambridge University Press, New York.
Livne-Tarandach, R., Hawbaker, B., Boren, B.L., Jones, C., 2015. Qualitative comparative analysis. In: Elsbach, K.D., Kramer, R.M. (Eds.), Handbook of Qualitative Organizational Research: Innovative Pathways and Methods. Routledge, New York, NY, pp. 156–167.
Lockett, A., Siegel, D., Wright, M., Ensley, M., 2005. The creation of spin-off firms at public research institutions: managerial and policy implications. Res. Pol. 34 (7), 981–993.
Lumineau, F., Barros De Oliveira, N., 2018. A pluralistic perspective to overcome major blind spots in research on interorganizational relationships. Acad. Manag. Ann. 12, 440–465.
Lumineau, F., Long, C., Sitkin, S.B., Argyres, N., Markman, G., 2023. Rethinking control and trust dynamics in and between organizations. J. Manag. Stud. 60 (8), 1937–1961. https://doi.org/10.1111/joms.12999.
Majuri, M., 2022. Inter-firm knowledge transfer in R&D project networks: a multiple case study. Technovation 115, 102475.
Mayer, K.J., Argyres, N.S., 2004. Learning to contract: evidence from the personal computer industry. Organ. Sci. 15, 394–410.
Mellewigt, T., Hoetker, G., Lütkewitte, M., 2018. Avoiding high opportunism is easy, achieving low opportunism is not: a QCA study on curbing opportunism in buyer–supplier relationships. Organ. Sci. 29 (6), 1208–1228.
Merton, R.K., 1942. The normative structure of science. In: Storer, M. (Ed.), The Sociology of Science. University of Chicago Press, Chicago, pp. 267–278.
Meuer, J., 2017. Exploring the complementarities within high-performance work systems: a set-theoretic analysis of UK firms. Hum. Resour. Manag. 56 (4), 651–672.
Meyer, M., 2003. Academic entrepreneurs or entrepreneurial academics? Research-based ventures and public support mechanisms. R D Manag. 33, 107–115.
Miles, I., 2005. Innovation in services. In: Fagerberg, J., Mowery, D., Nelson, R.R. (Eds.), The Oxford Handbook of Innovation. Oxford University Press, Oxford, pp. 433–458.
Mina, A., Bascavusoglu-Moreau, E., Hughes, A., 2014. Open service innovation and the firm's search for external knowledge. Res. Pol. 43, 853–866.
Miozzo, M., Soete, L., 2001. Internationalisation of services: a technological perspective. Technol. Forecast. Soc. Change 67 (2), 159–185.
Miozzo, M., Desyllas, P., Lee, H.-F., Miles, I., 2016. Innovation collaboration and appropriability by knowledge-intensive business services firms. Res. Pol. 45 (7), 1337–1351.
Misangyi, V.F., Greckhamer, T., Furnari, S., Fiss, P.C., Crilly, D., Aguilera, R., 2017. Embracing causal complexity: the emergence of a neo-configurational perspective. J. Manag. 43, 255–282.
Nahapiet, J., Ghoshal, S., 1998. Social capital, intellectual capital, and the organizational advantage. Acad. Manag. Rev. 23, 242–266.
Nelson, R.R., 2004. The market economy, and the scientific commons. Res. Pol. 33, 455–471.
Nelson, R., Winter, S.G., 1982. An Evolutionary Theory of Economic Change. Belknap Press, Cambridge, MA.
Nonaka, I., 1994. A dynamic theory of organizational knowledge creation. Organ. Sci. 5 (1), 14–37.
Nooteboom, B., van Haverbeke, W.P.M., Duijsters, G.M., Gilsing, V.A., van den Oord, A., 2007. Optimal cognitive distance and absorptive capacity. Res. Pol. 36 (7), 1016–1034.
Ordanini, A., Parasuraman, A., Ruberaet, G., 2014. When the recipe is more important than the ingredients: a Qualitative Comparative Analysis (QCA) of service innovation configurations. J. Serv. Res. 17 (2), 134–149.
Owen-Smith, J., Powell, W.W., 2001. To patent or not: faculty decisions and institutional success at technology transfer. J. Technol. Tran. 26, 99–114.
Park, Y., Mithas, S., 2020. Organized complexity of digital business strategy: a configurational perspective. MIS Q. 44 (1), 85–127.
Park, Y., Fiss, P.C., El Sawy, O.A., 2020. Theorizing the multiplicity of digital phenomena: the ecology of configurations, causal recipes, and guidelines for applying QCA. MIS Q. 44 (4), 1493–1520.
Perkmann, M., King, Z., Pavelin, S., 2011. Engaging excellence? Effects of faculty quality on industry engagement across disciplines. Res. Pol. 40, 539–552.
Perkmann, M., Tartari, V., McKelvey, M., Autio, E., Brostrom, A., D'Este, P., Fini, R., Geuna, A., Grimaldi, R., Hughes, A., Krabel, S., Kitson, M., Llerena, P., Lissoni, F., Salter, A., Sobrero, M., 2013. Academic engagement and commercialisation: a review of the literature on university-industry relations. Res. Pol. 42, 423–442.
Plewa, C., Korff, N., Baaken, T., Macpherson, G., 2013. University–industry linkage evolution: an empirical investigation of relational success factors. R D Manag. 43, 365–380.

Podsakoff, P.M., MacKenzie, S.B., Lee, J.-Y., Podsakoff, N.P., 2003. Common method biases in behavioral research: a critical review of the literature and recommended remedies. J. Appl. Psychol. 88 (5), 879–903.
Poppo, L., Zenger, T., 2002. Substitutes or complements? Exploring the relationship between formal contracts and relational governance. Strat. Manag. J. 23 (8), 707–725.
Poyago-Theotoky, J., Beath, J., Siegel, D., 2002. Universities and fundamental research: reflections on the growth of university–industry partnerships. Oxf. Rev. Econ. Pol. 18 (1), 10–21.
Ragin, C.C., 2008. Redesigning Social Inquiry: Fuzzy Sets and beyond. University of Chicago Press, Chicago.
Rasmussen, E., Mosey, S., Wright, M., 2015. The transformation of network ties to develop entrepreneurial competencies for university spin-offs. Enterpren. Reg. Dev. 27 (7–8), 430–457.
Rhoten, D., Powell, W.W., 2008. The frontiers of intellectual property: expanded protection versus new models of open science. Annu. Rev. Law Soc. Sci. 3, 345–373.
Rihoux, B., Ragin, C.C., 2009. Configurational Comparative Methods: Qualitative Comparative Analysis (QCA) and Related Techniques (Applied Social Research Methods). SAGE Publications, Thousand Oaks, CA.
Rothaermel, F.T., Agung, S., Jiang, L., 2007. University entrepreneurship: a taxonomy of the literature. Ind. Corp. Change 16, 691–791.
Ryall, M., Sampson, R., 2009. Formal contracts in the presence of relational enforcement mechanisms: evidence from technology development projects. Manag. Sci. 55, 906–925.
Sauermann, H., Stephan, P., 2013. Conflicting logics? A multidimensional view of industrial and academic science. Organ. Stud. 24 (3), 889–909.
Schartinger, D., Rammera, C., Fischer, M.M., Fröhlich, J., 2002. Knowledge interactions between universities and industry in Austria: sectoral patterns and determinants. Res. Pol. 31, 303–328.
Schepker, D.J., Oh, W.-Y., Martynov, A., Poppo, L., 2014. The many futures of contracts: moving beyond structure and safeguarding to coordination and adaptation. J. Manag. 40 (1), 193–225.
Schneider, M.R., Schulze-Bentrop, C., Paunescu, M., 2010. Mapping the institutional capital of high-tech firms: a fuzzy-set analysis of capitalist variety and export performance. J. Int. Bus. Stud. 41 (2), 246–266.
Scholten, V., Omta, O., Kemp, R., Elfring, T., 2015. Bridging ties and the role of research and start-up experience on the early growth of Dutch academic spin-offs. Technovation 45–46, 40–51.
Shane, S.A., 2004. Academic Entrepreneurship: University Spinoffs and Wealth Creation. Edward Elgar, Cheltenham, England.
Siegel, D.S., Waldman, D.A., Atwater, L.E., Link, A.N., 2004. Toward a model of the effective transfer of scientific knowledge from academicians to practitioners: qualitative evidence from the commercialization of university technologies. J. Eng. Technol. Manag. 21, 115–142.
Speldekamp, D., Knoben, J., Saka-Helmhout, A., 2020. Clusters and firm-level innovation: a configurational analysis of agglomeration, network and institutional advantages in European aerospace. Res. Pol. 49 (3), 103921.
Steinmo, M., Rasmussen, E., 2018. The interplay of cognitive and relational social capital dimensions in university-industry collaboration: overcoming the experience barrier. Res. Pol. 47, 1964–1974.
Swärd, A.R.S., Kvålshaugen, A., Bygballe, L., 2023. Unpacking the duality of control and trust in inter-organizational relationships through action-reaction cycles. J. Manag. Stud. 60 (8), 2091–2124.
Tartari, V., Breschi, S., 2012. Set them free: scientists' perceptions of benefits and costs of university-industry research collaboration. Ind. Corp. Change 21 (5), 1117–1147.
Tartari, V., Salter, A., D'Este, P., 2012. Crossing the Rubicon: exploring the factors that shape academic perceptions of the barriers to industry collaboration. Camb. J. Econ. 26 (2), 655–677.
Thursby, J.C., Thursby, M.C., 2002. Who is selling the ivory tower? Sources of growth in university licensing. Manag. Sci. 54 (8), 90–104.
Tsai, W., Ghoshal, S., 1998. Social capital and value creation: the role of intrafirm networks. Acad. Manag. J. 41, 464–476.
Uzzi, B., Lancaster, R., 2003. Relational embeddedness and learning: the case of bank loan managers and their clients. Manag. Sci. 49 (4), 383–399.
Vedel, J.B., Geraldi, J., 2023. How managers respond to paradoxical control – trust dynamics in interorganizational relationships over time: a constitutive approach. J. Manag. Stud. 60 (8), 2060–2090.
Villena, V.H., Revilla, E., Choi, T.Y., 2011. The dark side of buyer-supplier relationships: a social capital perspective. J. Oper. Manag. 29 (6), 561–576.
Von Nordenflycht, A., 2010. What is a professional service firm? Toward a theory and taxonomy of knowledge intensive firms. Acad. Manag. Rev. 35 (1), 155–174.
Wasko, M.M., Faraj, S., 2005. Why should I share? Examining social capital and knowledge contribution in electronic networks of practice. MIS Q. 29 (1), 35–57.
Wilhelm, H., Maurer, I., Ebers, M., 2021. (When) Are dynamic capabilities routine? A mixed-methods configurational analysis. J. Manag. Stud. 59 (6), 12789.
Williamson, O.E., 1985. The economic institutions of capitalism: firms. Markets and Relational Contracting. The Free Press, New York.
Williamson, O.E., 1991. Strategizing, economizing, and economic organization. Strat. Manag. J. 12 (S2), 75–94.
Woolthuis, R.K., Hillebrand, B., Nooteboom, B., 2005. Trust, contract and relationship development. Organ. Stud. 26 (6), 813–840.
Wright, M., Clarysse, B., Lockett, A., Knockaert, M., 2008. Mid-range universities' linkages with industry: knowledge types and the role of intermediaries. Res. Pol. 37, 1205–1223.
Zahra, S.A., Ireland, R.D., Hitt, M.A., 2000. International expansion by new venture firms: international diversity, mode of market entry, technological learning, and performance. Acad. Manag. J. 43 (5), 925–950.