The outset of U-I R&D relationships: the specific case of biological sciences

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Abstract

Purpose – The purpose of this paper is to draw insights from the actors-resources-activities (ARA) model and social capital literature to identify relevant activities shared by university-industry (U-I) actors prior to R&D cooperation.

Design/methodology/approach – Based on a qualitative methodology, a series of interviews were carried out with researchers from the biological sciences domain.

Findings – This study found that, at the outset of U-I links, companies' motivations are strongly organizational, while academics are motivated at a personal level. The interactions grow from low-risk activities to partnerships on complex tasks, and depend on relational resources framed within the ARA and social capital theories. Results showed that shared interests are present at the outset of U-I links and grow thereafter. Trust and commitment were not ubiquitous at the outset, but rather at later stages of the cooperation, as a result of the developed interdependencies.

Research limitations/implications – The combination of the ARA model and social capital in U-I links highlighted the different relationship levels (individual vs organizational), the disparities between early and established ties, and the interplay between low- and high-investment activities underlying researchers' relationships. Several managerial contributions are presented for universities to promote greater integration with industry partners.

Originality/value – A new direction of research is presented towards lower levels of U-I cooperation, taking into account the relational resources and the activities shared in each level. This work distinguished the different actors' motivations and clarified the role of trust and commitment at the outset of U-I links. This first assessment of Portuguese U-I interactions within the biological sciences provided valuable insights for both academics and practitioners.

Keywords Social capital, Portugal, ARA model, Biological sciences, Inter-organizational networks, University-industry links

Paper type Research paper

Introduction

Understanding university-industry (U-I) links assumes an increasing importance in the need to strengthen company's sources of competitive advantage when operating in turbulent environments. This study assumes that innovation is not exclusively dependent on the internal capabilities of a company, such as its R&D skills and its capacity to absorb external knowledge (Cohen and Levinthal, 1990; Hagemeister and Rodríguez-Castellanos, 2010) but can emerge and be built in the thin layer of actual exchange and knowledge-sharing between actors (Powell *et al.*, 1996). In other words, it depends on the networking and knowledge flow between all players involved

(Ouimet *et al.*, 2004). The business context in which a company develops its activity can greatly affect its success and growth (Håkansson and Snehota, 2002) in a sense that better collaborations (in the qualitative sense) may foster improved outcomes for the actors involved (Mora-Valentin *et al.*, 2004; Raesfeld *et al.*, 2012). Consequently, networking activities allow R&D partners to acquire innovation-prone tacit and explicit knowledge, crucial for competitive advantage (Gilsing and Nooteboom, 2005; Story *et al.*, 2009). This perspective is particularly relevant for most knowledge-intensive economic activities, such as those relying on biological sciences (Gertler and Levitte, 2005). It is also important to notice that "studies of networking have mainly focused on private sector organisations and have mostly used an organisational perspective ignoring collective network-level views" (Lundberg and Andresen, 2012, p. 429).

On the other hand, universities around the world are increasingly eager to collaborate with external partners. The academic mission of teaching and advancing fundamental research continues to be the major priority for which there is a growing need of external funding (Lee, 2000; Plewa, 2005). Yet, universities are expected to impact on society and economy at regional and national levels. R&D cooperation with business partners is instrumental in this regard (Kauffeld-Monz and Fritsch, 2013), and universities can be valuable partners for companies, as they are usually not competing counterparts of their research activities (Santoro and Betts, 2002; Welsh *et al.*, 2008). Moreover, the combination of heterogeneous sources of knowledge can lead to an increase in radical innovation (Gilsing and Nooteboom, 2005; Tödtling *et al.*, 2009), as well as lower R&D expenses for both parties (George *et al.*, 2002).

The resources required to promote collaborative innovation can be financial, intellectual and physical, as well as social capital (Lundberg and Andresen, 2012), each having a distinct role in the development pipeline. However, the availability of resources *per se* does not guarantee successful cooperation. Actors involved in the process must be able to exchange and combine the different resources to achieve novelty beyond results obtained individually (Håkansson and Snehota, 1995). In this sense, university and industry actors need to allow their partners access to each other's resources, expecting that activities derived from their use will generate synergy. This particular aspect of resource sharing is key in R&D cooperation. R&D involves high-risk activities, in most cases with no guaranteed results (Blomqvist *et al.*, 2005). This way, cooperative relationships tend to take place between trustworthy and committed partners (Mora-Valentin *et al.*, 2004; Frasquet *et al.*, 2011), where it is fundamental to be able to depend on and trust each other, in view of the commercially sensitive and tacit nature of the knowledge involved (Santoro and Saparito, 2003; Bruneel *et al.*, 2010).

Considering the previous arguments, and in order to reach a successful U-I cooperation, partners need to mutually develop their relationship prior to sharing their resources. The activities that precede the level of R&D cooperation can be crucial to align their interests, deriving from different organizational objectives (Plewa, and Quester, 2007). Moreover, trust and commitment between partners can contribute to overcome functional conflicts, leading to the accomplishment of mutually valuable outcomes (Morgan and Hunt, 1994; Frasquet *et al.*, 2011). In our view, the interactions that shape U-I R&D cooperation should be approached as a continuous and developing relationship, with various common activities and resources invested throughout time. Moreover, neither relationships nor organizations exist in isolation but rather depend on each other (Hagedoorn, 2006; Håkansson and Snehota, 1995). These arguments provide the basis for our choice of the Actors-Resources-Activities (ARA) model

(Håkansson and Johanson, 1992), along with key concepts from social capital theory, to understand the interactions between U-I partners at the outset of an effective R&D cooperation. Although both theories have been discussed together previously (Lundberg and Andresen, 2012; Finch *et al.*, 2010), these have not yet been applied to the outset of U-I R&D relationships. Hence, this paper attempts to identify relevant activities shared by U-I actors prior to research cooperation, as well as the importance of relational resources (trust, commitment, shared interests) in the process towards joint R&D activities. Data used in this study were collected by means of interviews with researchers from the Portuguese biological sciences community. Importantly, this preference for qualitative data (Cassell and Symon, 2004) rests on the fact that it allows a deeper understanding of the language shared by R&D partners, provides a richer context insight, as well as an assessment of their common conceptual construction of the developing relationship.

We proceed by first presenting the literature review, followed by the research methodology. Next, the data collection and analysis are presented. Then, the major findings are analysed followed by discussion and implications for both theory and practice.

Literature review
From dyadic transactions to network relationships
U-I cooperation and its impact on innovation has been a long-standing topic of analysis in many fields of knowledge, ranging from management, economics and sociology to science policy (Bozeman, 2000; Agrawal, 2001; Leydesdorff and Meyer, 2003; Brimble and Doner, 2007; Perkmann and Walsh. 2009). In recent decades, much research has been carried out on the processes of technology transfer, in order to measure innovation performance and its impact at regional and national levels (Mowery *et al.*, 1996; Siegel *et al.*, 2001; Hemert *et al.*, 2012; Thornhill, 2006). Several authors emphasized the relevance of transferring explicit knowledge in order to generate the innovative outcomes that companies need to maintain their competitive advantage (Lehrer, 2007; Powell *et al.*, 1996; Rosiello, 2007). Nonetheless, there is a growing body of literature addressing the relational and social side of innovation aiming at understanding the relational investments and processes that institutions go through in order to reach innovative outcomes (Landry *et al.*, 2002; Alguezaui and Filieri, 2010; Pérez-Luño *et al.*, 2011). This putative change of paradigm implies that U-I links are treated less as transactions and more as relationships, which are built up over time, and can be leveraged to access critical resources. In a sense, the developing relationship itself becomes a unique and valuable resource that competitors cannot access or copy, requiring investment to be maintained (Lavie, 2006; Lundberg and Andresen, 2012). The use of this unique resource should enable a positive feedback loop, continuously improving the quality of the interaction between the partners and increasing their relational interdependence.

Another key aspect of U-I cooperation is the fact that actors can be involved in simultaneous relationships with different partners (D'Este and Patel, 2007; Protogerou *et al.*, 2012). Research on networks of co-authorship and project membership showed that university and industry have very diverse networks with multiple stakeholders (Vonortas, 2012; Beaudry and Kananian, 2013). Moreover, for any given institution, each link has the capacity to positively or negatively influence every other existing or potential link, embodying the opportunities and constraints promoted by network interactions (Baraldi and Strömsten, 2009; Rowley, 1997). As resources are limited,

institutions can only invest in selected relationships, which forces the study of U-I relationships to consider the network effects and the structural dependence of actors, moving away from dyadic studies, often based on the relationship with the main partner (Plewa ,and Quester, 2008; Morgan and Hunt, 1994). Concurrently, when a network is formed, the ARA model and the Industrial Marketing and Purchasing (IMP) group research stream advocate a structural and relational dependence between the actors (Baraldi *et al.*, 2007; Ford *et al.*, 2008). Three layers that involve the network of interactions describe this dependence in the ARA model: the actors, the resources and the activities (Håkansson and Snehota, 1995). Actors share bonds between them, through which resources flow and activities are performed, creating mutual value. The exchange and combination of resources are tied to relationships developed in dyads, embedded in wider networks. The progress of a dyadic relationship is not transferable between actors, representing the relational interdependence of the network. Activities have links between them and reinforce the bonds between actors. Likewise, when two actors perform a joint activity using their resources, it may limit the execution of that same activity with other actors in the network, revealing the structural interdependence of the network. These actor bonds grow from simple, low-involvement interactions between institutions to mature relationships when the partners feel confident to invest further, in order to secure the benefits of a greater integration (Trkman and Desouza, 2012). Just as in B2B networks, actors' structural and relational dependence can be observed in U-I links (Lundberg and Andresen, 2012), impacting the type of activities and resources available from the outset and throughout the development of the relationship between actors.

Inter-organizational links and activities prior to R&D cooperation
U-I relationships can easily be perceived as inter-organizational links. The most immediate requirement is that two institutions provide a bridge for their researchers to foster and maintain the collaboration. In the IMP literature, these bridges were described to develop because organizations acknowledge they need external partners for their everyday activities, without whom their opportunities for development become limited (Anderson *et al.*, 1994; Håkansson and Ford, 2002). Consequently, the structural links driven by organizational motivations should empower joint activities and resource sharing. The interdependence between actors on the two sides of the bridge is regarded as an opportunity for cooperation, as it facilitates knowledge-sharing, and allows partners to build their competitive advantages (Baraldi *et al.*, 2012).

There are diverse motivations to initiate an inter-organizational link towards R&D cooperation. Companies enjoy lower risks and lower R&D costs, a favourable public image and reputation, and easier access to frontier knowledge and skills. For their part, universities are motivated by the need for external funds to support their research activities, as well as producing positive effects on society through improved regional, economic development, education, and the exploration of new ideas for future projects (Lundberg and Andresen, 2012; Veugelers and Cassiman, 2005; López-Martínez *et al.*, 1994). Based on their own mission-based organizational motivations, U-I partners are expected to seek one another and, similar to B2B links (Ganesan, 1994; Dwyer *et al.*, 1987), collaboration could start with low-investment low-risk activities, such as service-provision or buyer-seller exchanges. This starting process most likely contributes to clarifying the orientations and goals of each organization, and the establishment of a common ground for future collaborative works, as actors may be more receptive to each other's ideas and therefore more willing to invest further if there are shared interests and mutual value.

As acknowledged by Jaakkola and Hakanen (2013) value derives "from the benefits and sacrifices perceived by the actor in the offering and the related exchange".

R&D literature acknowledges several activities used to foster U-I links (D'Este and Patel, 2007; Bekkers and Freitas, 2008), but it is not clear as to which one/s ensure/s the relationship development. This entails greater dependence between actors, which may shift from considering themselves each other's clients to being partners as well. In this line, do the activities also change along with the relationship? Would that mean that mutual service provision continues, despite more complex collaboration? The literature seems clear that the significance of the shared resources and the consequent level of the actors' dependence evolve with the relationship (Mouzas and Ford, 2012), making it more likely that the degree of complexity of the activities changes as well. This work proposes that this change encompasses adding more shared tasks with consequent increased partner reliance, and not substituting service provision by other tasks. Thus, supplier-customer activities may continue while more complex tasks are added to the relationship. To the best of our knowledge, in addition to the limited data on how the interaction between actors tends to start, in particular in the biological sciences domain on which the present work focuses, there is little research evidence on how the relationship development affects the activities performed by U-I actors. All things considered, the following research propositions are built:

P1. Organizational motivations of both university and industry actors are the main promoters of the activities at the beginning of a U-I relationship.

P2. Low-investment and low-risk activities at the beginning of a U-I link will continue throughout the relationship, while more complex tasks are added as the relationship matures.

The role of relational resources prior to R&D cooperation
The IMP research stream, through the ARA model, supports the theory that, in any relationship, resources are essential for each actor to develop activities. As resources and activities become more complex, the capacity for a single actor to manage them becomes more limited, requiring the inclusion of further actors for collective leverage (Cantù *et al.*, 2012). The capacity to do this is dependent on the actor's capability to engage in interactions that generate joint gains (Mouzas and Ford, 2012). This was suggested for inter-firm cooperation, but it should also be true for any other knowledge-based activities, such as those within U-I partnerships.

IMP focuses on the exchange and combination of financial, intellectual and physical resources, and less often on relational resources, such as social capital. According to Batt (2008), social capital is underexplored in B2B marketing, which it should usefully contribute to with key insights into many of the IMP concepts. As Partanen *et al.* (2008) observed, while the IMP-driven research tends to focus mainly on organizational actors and business networks, social capital research tends to consider the individual's social relationships. Similarly to Batt (2008, p. 488), we view social capital as "the mobilization, use and benefits gained through accessing present and future resources" through social, intra- and inter-organizational networks. Common features exist between these research streams, encompassing constructs such as commitment, trust and shared interests, amongst others. In the context of business networks, IMP has acknowledged the role of these relational resources in cooperation, as engaged actors develop mutual orientation and commitment over time, gradually assuming a higher degree of interdependence (Håkansson and Snehota, 1995). Concurrently, trust and dependence were considered elementary qualities in customer-supplier relationships within networks, with actor interdependence increasing as

the relationship develops (Laaksonen *et al.*, 2008). As such, in time, actors are more aligned with their partners' interests and objectives, and their resources can be leveraged for mutual strategy formulation (Baraldi *et al.*, 2007). Similar phenomena are expected in a U-I setting, as actors increasingly share research interests and resources in their cooperation, despite their organizational differences (Lundberg and Andresen, 2012).

In the context of U-I links, the combination of relational resources embedded in actor bonds, such as trust, commitment and shared interests, could be directly tied to the successful execution of tasks. In the case of inter-firm links, the successful development of R&D cooperation is simultaneously dependent on trust and formal contracts (Blomqvist *et al.*, 2005). However, unlike contracts, trust is more far reaching in the relationship between actors. Trust can be viewed as the belief that a potential partner is honest, fair and reliable, irrespective of the ability to monitor or control the other party (Mayer *et al.*, 1995). Thus, a trustworthy relationship provides the conditions for assessing the predictability of future actions based on past interaction and promises, and mainly reduces the perception of risk, associated with opportunistic behaviour (Dwyer *et al.*, 1987; Morgan and Hunt, 1994). In view of the high-cost high-risk character of research, even if applied in nature, trust should be present from the outset in U-I relationships in order to enable greater integration and resource sharing. According to Blomqvist *et al.* (2005), within inter-firm R&D cooperation, a base level of trust is required to initiate any cooperation or to even draft a contract. This work expects to understand if U-I relationships behave similarly.

University and industry actors have different organizational cultures, namely regarding secrecy vs free dissemination of knowledge, which might jeopardize effective alliances (George *et al.*, 2002; Plewa ,and Quester, 2007). Asymmetries of an identical degree can be found in inter-firm collaborations (Blomqvist *et al.*, 2005). This could have a significant and direct impact on the development of trust, commitment and interdependence. Therefore, partners need to find compatible matches to foster adequate cooperation. Despite the acknowledged differences between academia and industry, it is possible to deal with those differences through close and direct involvement, progressively closing the gap generated by cognitive distance (Rosiello, 2007). Intuitively, U-I cooperation could consider sharing any type of resources, namely information, tacit or explicit knowledge, technology, materials or samples. However, in order to reach this exchange level, partners should be comfortable working together and committed to their shared tasks. Specifically, commitment is often referred to as an attitude of attachment and an intention to continue a relationship (Morgan and Hunt, 1994; Dwyer *et al.*, 1987). As previously mentioned, investments in relationships enhance parties' credibility, reducing uncertainty and the risk of opportunism (Achrol and Gundlach, 1999). Whilst past works have shown that both trust and commitment are constructs present in U-I relationships (Frasquet *et al.*, 2011; Plewa, 2005), little evidence was found on how those relational resources are present at the outset of the relationship. In successful relationships, both constructs are expected to grow as relationships progress, even if conflict is present (Morgan and Hunt, 1994). Based on these arguments, the following research propositions are proposed:

P3. Shared interests should be identified at the outset of the U-I link and grow alongside the relationship, allowing increasing resource sharing.

P4. Trust and commitment are required for the outset of U-I links and should increase alongside the relationship, allowing greater partner interdependence.

Following the explanation of the methodology used in the present work, the research propositions are contrasted with the collected data from the interviews.

Methodology

Research background

Given the fact that the objectives of the study were more related to understanding than assessing, the outset of U&I relationships are analysed using a qualitative methodology. The logic behind this approach is to place emphasis on theory development as a process, based on interviews with a semi-structured script, instead of assessing or testing pre-defined hypotheses. Furthermore, the focus of this study – biological sciences community in Portugal – was chosen according to several criteria. The biological sciences provide knowledge and technology to many different industries, such as medical, food, environment, agriculture and pharmaceutical industries, as well as industrial processes, such as plastics or beverages production, making it a relevant area of study in terms of the amount of opportunities for U-I cooperation. Additionally, the research units in Portugal that work in this broad scientific field enclose 46 per cent of the total Portuguese research full time equivalent (FTEs) working on non-humanities and non-social sciences units (FCT, 2014). The choice of narrowing the study to the Portuguese scientific community is based on the exceptional way Portuguese R&D activities evolved over the last 20 years. During that period, and according to data from Eurostat and the Portuguese Science and Technology Foundation (FCT), the number of FTEs and the associated scientific production increased exponentially, from the very low base level of 1.04 FTE/1,000 inhabitants in 1994 (50 per cent of the EU average in 1993) (Eurostat, 2013; FCT, 2014). Unlike other countries in the EU, Portugal has a very young scientific community. This configures the field of biological sciences in Portugal as very dynamic, providing a good population to understand the outset of U-I relationships.

It is worth noting that, according to the latest European Community Innovation Survey (CIS 2010 data in FCT, 2012), in terms of collaboration partners for R&D tasks, Portugal compares unfavourably to the EU average. When compared to EU figures, the potential partners that Portuguese companies least search for are universities and other institutions of higher education, along with private consultancies and research laboratories (FCT, 2012, p. 223). Moreover, U-I cooperation within the EU members relies considerably on European funding. Each year, there are projects funded by European framework programmes, supporting sound research proposals from U-I consortia. Nevertheless, there is no information in the literature on how these consortia came to be, and what steps partners went through in order to reach such an involvement towards a funding opportunity. At national level, similar funding programmes exist, though the degree of funding is much smaller, and they are less frequently committed to the U-I interplay, with less than 1 per cent of total funding allocated to projects submitted by industrial parties (FCT, 2012, p. 187).

Sampling process and sample size

The key criteria underlying the selection of individuals for our study was relevance rather than representation (Perry, 2000). This study adopted a theoretical sampling in order to gain a deeper understanding of the outset of U-I R&D relationships. Specifically, this sampling proceeds not in terms of a sample of a specific group of individuals, but in terms of concepts, their properties, dimensions and variations (Corbin and Strauss, 1990). Accordingly, academic participants were selected from research centres in Portuguese universities that had been recently distinguished in the *Times* World University Ranking (region: Europe). The sample included 11 academics from five research centres working within the biological sciences domain covering a wide range of experiences in research collaboration (Table I). Nine university

	Profile of the interviewee	Area of research	Experience in U-I links
I1	Technical director of SME	Agricultural biology services	Mostly services and small projects with universities in the Lisbon area
I2	R&D laboratory manager of SME	Molecular biology services	Service provision and research collaborations with national and international universities. Participant in R&D projects funded by national and international agencies
U1	Tenure professor – University in Lisbon	Biotechnology	Research collaboration with companies mostly in national projects (service provision and R&D with shared students)
U2	Tenure professor – University in Lisbon	Biotechnology	Over 20 years of research collaboration with companies, mostly in service provision projects
U3	Tenure professor – University in Lisbon	Biotechnology	Over 15 years of research collaboration with several companies, mostly in national projects (service provision and R&D)
U4	Tenure professor – University in Lisbon	Biotechnology	Over ten years of continuous collaboration with a limited number of companies, mostly in national projects (service provision and R&D)
U5	Tenure professor – University in Lisbon	Molecular biology	Over ten years of research collaboration with few companies, both in national and international projects (service provision and R&D with shared students)
U6	Senior research fellow affiliated with a University in Porto	Molecular biology	Over ten years of interaction with multinational companies, mostly in licencing deals from products developed by a university team
U7	Tenure professor – University in Braga	Biotechnology	Over 20 years of research collaboration with companies in national and international projects (service provision and R&D)
U8	Tenure professor – University in Braga	Environmental biology	Limited experience with companies, recent R&D services for a multinational company
U9	Tenure professor – University in Braga & Founder of a biotech SME	Biotechnology	Over 20 years of research collaboration with companies in national and international projects (service provision and R&D with shared students)
RCD1	Research centre director – University in Lisbon	Biotechnology	Overview of centre's U-I activities
RCD2	Research centre director affiliated with a University in Porto	Molecular biology	Overview of centre's U-I activities

Note: Research area and U-I experience data collected during the interviews

Table I.
Information from
interviewees of the
present study

researchers and the two research centre directors (RCD) were contacted and agreed to participate in our study. One of our academic interviewees was both a university researcher and founder of a biotech SME, therefore providing a more comprehensive view of both sides of the relationship. Subsequently, four researchers from the private sector were contacted for an interview regarding the relationship already described by the university party, but only two of them were available for our study.

Research instrument and unit of analysis
Our data was collected using a semi-structured script developed from relevant literature, as recommended by Eisenhardt (1989) and Yin (1994). A guideline for face-to-face interviews was established, accommodating concepts from the IMP research stream with contributions from social capital. The procedure was developed in order to give interviewees the ability to describe his/her reality free of constraints with regard to each question. University participants were encouraged to select one or more successful collaborations ongoing between 2008 and 2012, as long as these included at least one private sector partner. In the interviews, university and company researchers were asked to describe the outset and evolution of the relationships with their R&D partners; detail how trust and commitment developed and why these elements were important; and identify the resources (supplied and received) and how they affected the relationship.

Face-to-face interviews averaging 45 minutes were conducted between June and October 2012. The collected data consisted of nine independent cases of self-reported U-I links. The corresponding unit of analysis is the cooperative relationship from the perspective of its participant(s). Additionally, the interviews with the two RCDs gave a further contextual view of the importance of U-I links in the overall activities of the research centres. The number of interviews (Table I) was not higher because a clear level of data saturation was reached (Bowen, 2008), in accordance with the guidelines of four to ten cases, as proposed by Eisenhardt (1989).

Data collection and analysis
Nine participants allowed the audio record of the interviews, while extensive note taking was used for the remaining interviews. The recorded audio data were transcribed verbatim and compared to the notes of the other interviews. The contents of the transcripts (from notes and audio) were then analysed following three concurrent stages, as proposed by Miles and Huberman (1994): data reduction, data displays and conclusion verification. The results were grouped according to the four research propositions, in order to facilitate the assessment of data match with our theoretical propositions.

Findings
Organizational motivations at the outset of U-I links (P1)
From the literature review, U-I links are promoted first and foremost by organizational motivations. Whilst academics seek industry in line with the university's mission for education, research advances and regional development, industry contacts the university driven by a quest for easier access to frontier knowledge and skills to foster innovation. The interviews conducted with researchers from both groups evidenced diverse motivations, but not only organizational.

The two RCDs interviewed acknowledged the capacity of their research centres to attract industrial funding, mostly through service provision derived from frequent requests for their research competences and equipment. As the national public funding of research centres is progressively reducing, both directors looked at research services as a strong drive fostering U-I links, as the resulting external funds allowed keeping their fundamental research activity alive. In parallel with these reports, both industry researchers (I1, I2 in Table I) mentioned the importance of university knowledge for their activities. Since their university partners (U3, U5 in Table I, respectively) were working in complementary areas to their business activities, the knowledge produced was identified as a sector-specific and innovation-prone resource. These partners were

willing to start a relationship based on matching motivations. Likewise, the majority of academic interviewees described similar alignments. However, in several unsuccessful cases reported by researchers (U1-U4), companies expected universities to develop new products without any compensation (financial or otherwise), showing no interest for the university's motivations. These unsuccessful cases were not deeply explored in the interviews. Nevertheless, they contributed to highlight that common organizational motivations are needed to establish successful cooperation.

Alongside these strictly organizational drives, nearly every interview revealed interpersonal history underlying the initiation and maintenance of a U-I link. These links elaborate from more to less interpersonal contacts as follows:

- a colleague and a family member introduced U9 to its future industrial partners;

- U5 knew the CEO of the company personally before any work was shared;

- U2 and U3 had several ongoing U-I links based on personal acquaintances that facilitated the commencement of several master and doctoral theses;

- U7 started the link from a personal contact developed during a workshop;

- U1 and U4 described relationships driven by contacts established by former graduation students working at companies; and

- U6 developed a close work relationship with the industrial partner from a sustained buyer-seller interaction.

In this sense, while inter-organizational motivations were recognized as important promoters of U-I activities, they are not the main drivers underlying the outset. Accordingly, most academic researchers pinned the success of their cooperation to the establishment of interpersonal links, rather than to the alignment of organizational drivers. In the words of U1: "the link to the company would not be so easy if there was not a previous, almost personal, relationship [with the former student working there]". Moreover, academics referred more often to personal motivations, such as funding for their research, opportunities for career development and individual recognition. Thus, our *P1* – organizational motivations are the main drivers of the outset of U-I links – was not confirmed in the interviews. Quite the opposite, these data suggest that interpersonal links are the main drivers.

The evolution of shared activities as U-I relationships mature (P2)
Consistent with the literature on B2B links, U-I actors are expected to start their collaborations with low-risk and low-investment activities, in order to clarify their own orientations and goals, as well as assessing the quality of each other's work. More complex tasks could be added over time, as the relationship matures. This was confirmed from the perspective of both university and industry researchers. Industry researcher I1 had previous contacts with U3, related to mutual service provision, and this had recently evolved into the development of a doctoral thesis, expected to result in innovative services to be provided by the firm to the market. In the meantime, mutual service provision persisted whenever specific laboratory analyses were needed. On a similar note, industry researcher I2 reported the following: "In this case [of the relationship with U5], they were our clients, using services that we provide, therefore in a supplier-customer relationship. […] We are now trying collaboration not as supplier-customer but as partners [sharing R&D tasks in a funded project]. The relationship evolved, which does not mean that we will not keep each other as suppliers in other

situations. […] It evolved into a partnership because we got to know them. […] A deeper relation in non-client-to-customer terms came from going along with each other. There were synergies".

Likewise, academic researchers recognized this relational evolution, tied to the level of investments and risks in activities. All successful experiences reported by U1 started with service provision and then evolved into the development of master theses, with part of the work conducted in close collaboration with company members. U9 started a U-I link from smaller tasks of interest to a company partner, and through continuous interaction over time started engaging in common projects, which ultimately led to a shared doctoral student working in the company environment. Researcher U4 had a similar account: "The idea of working together came from the company, because they wanted a service that we could provide. In 2001, in Portugal, very few people were working in that area […]. We then proposed to add something beyond the service provision so we could go a bit further […] that led to the master thesis and now the doctoral thesis of one of my students". While it is not transcribed, in U4's experience, simultaneous service provision and research tasks for both master and doctoral theses lasted several years. Finally, the most recent experience of U7's in U-I links was the participation in a project funded by the FP7-SME programme, which consisted mostly of service provision activities of interest to SMEs spread throughout Europe. Within the project tasks, U7 interacted mostly with one of the SMEs, but did not produce any research papers, which was presented as a significant drawback. The benefits for U7 consisted mostly of available funds for scholarships and attending conferences. In the interview, U7 referred being available for further work with this company, as long as some academic outputs could be ensured, namely through research that was less focused on problem-solving for a single company.

All taken, the majority of the studied cases (six out of nine) evolved from supplier-customer relationships to sharing post-graduation and/or doctoral students, which necessarily involved more human resources, time, money and laboratory supplies to keep the cooperation alive. In some cases, but not all, interviewees kept low- and high-investment activities going at the same time. In line with the interviewees' accounts, *P2* – low-investment low-risk activities, characteristic of the outset of U-I links, may last and occur simultaneously with other more mature types of cooperation – was confirmed.

U-I shared interests and resource sharing (P3)

U-I institutions have distinct roles and objectives in society, and their mutual engagement should only be explored if shared interests and mutual benefits can be acknowledged. Given their putative ability to complement each other in knowledge creation, development and exploitation, it is expected that interactions grow towards cooperation with greater mutual benefits, as a result of significant sharing and a combination of strategic resources.

Successful U-I links reported by interviewees were undoubtedly dependent on the identification of shared interests and mutual gains. This important step was echoed throughout the interviews with academic and company researchers, as well as RCDs. Academics described interest in knowledge outputs, such as theses, papers, ideas for future projects, and patents (by decreasing order of mention frequency). Companies identified the U-I link as beneficial to their national reputation, as well as to their capacity to develop new services/products. According to I2, co-authoring research papers, for example, served the interests of both parties, as long as that research could

later be turned into a market application. Moreover, researcher U3 saw the work of previous master theses in collaboration with companies grow into two independent R&D project applications for national funding with companies being partners. U4, on the other hand, expanded a series of service provision tasks to a research project, whose expected results were of interest to the company, reason why it was willing to invest more financial and physical resources. Finally, U9 explicitly reported another level of growing interest in the collaboration with industrial partners. Their joint work led to a new research line at the university, and a new spin-off company based on products developed within the scope of a shared doctoral thesis. This way, *P3* is confirmed – shared interests were identified at the outset of successful U-I cooperation, and frequently grew as a result of partners sharing more complex tasks, implying increasing resources.

Trust, commitment and partner interdependence (P4)
In the interviews, trust and commitment were referred as *sine qua non* conditions for R&D cooperation by the interviewees, except for the two RCDs with whom the issue was not discussed. Academics and company researchers very clearly distinguished the level of trust inherent in cooperation activities from the level inherent in mere service provision. The latter was considered much lower, and was associated with lower engagement or commitment. Actually, some interviewees (U1, U3, U6, U8) reported that initial service provision activities were often associated with distrust, which could only be overcome with the positive and significant national or international reputation that the company had in the marketplace at the time of their first interaction. From experience, U3 pointed out that trust, or lack of it, is the single most significant barrier to more frequent U-I cooperation in Portugal, since both universities and companies frequently have a mutual a priori sense of distrust in their first interactions. Furthermore, U1 and U3 explained that, from the university's perspective, distrust comes from the feeling that the company will not fulfil its promises, which often included not paying for the research services provided by academics, despite the contracts signed beforehand. This statement aligns with Luhmann's (1979, p. 72) definition of distrust as a "positive expectation of injurious action". Similar findings were reported by Seppänen and Blomqvist (2006) on inter-firm relationships.

When addressing their successful experiences, academics and company researchers did not describe trust as blind confidence in the correct execution of programmed tasks, but rather as an expectation of fulfilment that was accompanied by mutual supervision. The definition cited previously (Mayer *et al.*, 1995) was less dependent on this capability. This suggests that Portuguese researchers end up trusting their partners in the long run, while being aware of each other's self-interests, similar to what has been described as calculative trust (Doney and Cannon, 1997). This calculative trust was useful in cases of research issues and minor conflicts reported by U3, U4, U7, U8, U9 and I2. Supervision helped partners become aware of, and resolve issues with further and closer collaboration. This type of functional conflict was frequently associated with growing trust and commitment, because partners acknowledge a mutual effort in trying to accomplish the promised activities. The majority of interviewees, with the exceptions of U1, U2 and U7, experienced an increase of trust and commitment throughout their relationships. Researcher U9 explained that mutual trust and commitment to shared activities were instrumental for relationship continuity and partner dependence. This was important for both parties because it allowed investments in future opportunities, such as applications to funding calls at the European level. Likewise, as U3 explained, "service

provision and research outsourcing can be used as opportunities for companies to know the universities and vice-versa and to establish trust for other types of projects". Currently, their expectation is that ongoing national research activities with companies might one day pave the way for more integrated, internationally funded projects.

Summing up, at the outset of U-I links, it is not consensual that trust is present, while commitment to shared tasks was mostly enforced by signed contracts, since distrust was significant, and only softened by the partner's reputation. Furthermore, at the level of R&D cooperation, the presence of trust and commitment is nearly unanimous, with partners acknowledging significant resource interdependence. *P4*, in line with previous research (Seppänen *et al.*, 2007; Plewa, 2005), considers that trust and commitment are mandatory for the outset of U-I collaborations, and should increase during activity development along with partner interdependence. However, according to the results in the present work, U-I collaborations start even without trust and commitment, although these must grow in order for the collaboration to progresses to shared R&D activities. Therefore, *P4* was only partially confirmed, in that trust and commitment are mandatory for partners' growing interdependence and project success, but not for the outset.

Discussion
This section reviews the most salient findings and explains the activities and resources involved at the outset of U-I R&D cooperation relationships. In the literature, these relationships are mostly addressed from the point of view of the aftermath innovation and economy achievements. These are the final outcomes of dynamic, complex and long-lasting networks which nodes are both organizations and individuals. In that context, the IMP Group focused on the inter-organizational links through the use of the ARA model, which has been mostly explored in the B2B context (Cantù *et al.*, 2012; Håkansson and Snehota, 1995). Lundberg and Andresen (2012) explored the ARA model in U-I R&D cooperation with the inclusion of further actors, like governmental bodies, financiers and facilitators, while acknowledging that established interpersonal relationships are important for cooperation between different actor categories, improving communication and lowering cultural barriers.

Relying on both the ARA model and social capital theory the present work aims at understanding the outset of the relationships that enable effective U-I cooperation. The comparison between the interviews and the literature led us to develop a diagram representing the evolution of the actors' activities as a function of the investment of relational resources, such as trust, commitment and shared interests (Figure 1). Both axes of the diagram include more than one construct. The horizontal axis should be read as a gradual though non-quantitative increase of relational resources shared among actors, while the vertical axis should be read as an increase in mutual value created as a result of growing actor bonds, resource ties and activity links (ARA model premises). This diagram was used in support of the discussion that follows.

In line with recent contributions, the increasing availability of relational and non-relational resources led U-I actors to participate in activities of greater interdependence and integration accruing value in a network context (Jaakkola and Hakanen, 2013). The increase in non-relational resources (financial, physical and intellectual) as actors became more interdependent, is not portrayed in the diagram. However, the present work found that the accomplishment of more complex activities (towards the right side of Figure 1) demands not only high levels of resources and capabilities but also a combination of these into a number of activities, similarly to previous contributions of
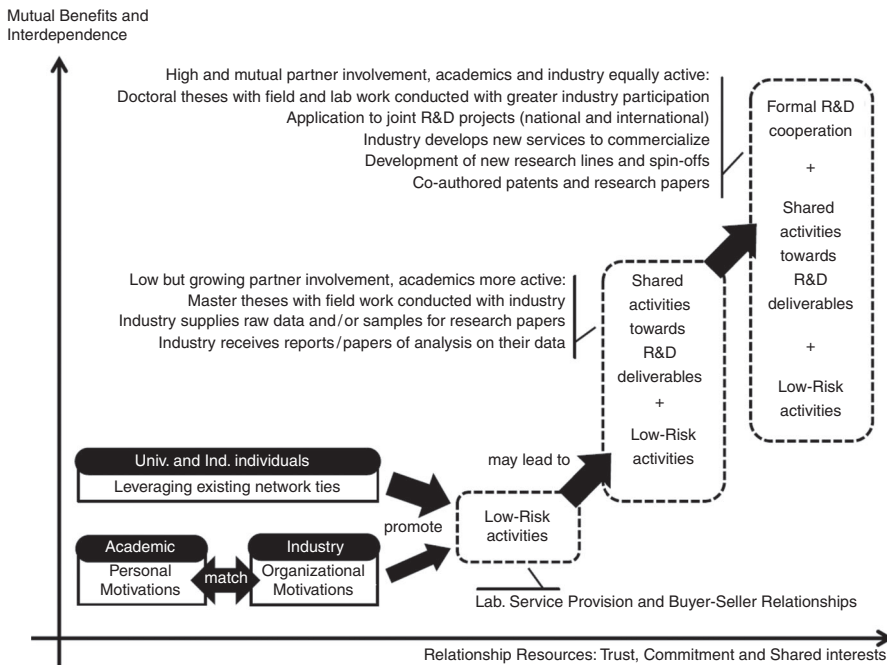
Figure 1.
Diagram of the
cooperation
continuum – the
evolution of U-I
actors shared
activities and mutual
value as a function
of the investment of
relational resources

the IMP Group in the B2B context (Cantù *et al.*, 2012; Mouzas and Ford, 2012). These dynamics reflect the findings of *P3* in which increased resource sharing derives from maturing relationships.

In Figure 1, the extent of U-I cooperation was divided into three levels representing the overall dimension of the actor bonds. Nevertheless, these levels are not to be understood as strict stages of the process. From the analysis, cooperation was realized as a continuum rather than a stage driven process. While advancing to a higher level of cooperation, actors may keep engaged in low-risk tasks, as these activities also contribute to a constant improvement of their relationship and resource ties. Proceeding to the next level of activities is suggested to be dependent upon good execution of previous ones, as mentioned frequently by interviewees, highlighting the role of activity links from the ARA model. *P2* is in accordance with this rationale.

As mentioned above, the findings of the present work did not confirm *P1*. Much the opposite, the process to develop a U-I work relationship starts with two main outset activities: leveraging of existing personal direct or indirect network ties; and matching inter-organizational and interpersonal motivations. Concerning the first outset activity, ties can originate from formal acquaintances within the participating organizations (co-workers or other research teams) or from informal relationships developed elsewhere (family, common friends or others). It is important to highlight that the interviewees mentioned that without the first activity (i.e. leveraging of network ties) the relationship is much harder to start. Consequently, the amount of relational resources (or social capital) available is lower and it appears to slow down (but not impede) the development of long-term U-I relationships. In what concerns the second outset activity, failure to find a match between each party's motivations ceases the link. Interviewees described unsuccessful cases like this. It was found that companies and

their employees usually understand very well their institutional motivations and objectives towards U-I cooperation. In particular, it was perceived that companies seek universities, or research groups, or even an isolated researcher. This was most often associated with an organizational initiative. However, this was different from the academic end. Ultimately, it was never the university as a whole that approached a company, but rather the research group or, more frequently, the individual researcher that took the initiative. As such, the major drivers from the academic side were mainly individual motivations, and the development of interpersonal relationships, which do not collide with the university's mission. Depending on the private sector (i.e. companies) or the university's end of the exchange, there is often an uneven, individual and organizational weight driving the outset of U-I connections. These observations stress that research of developing U-I links should be able to encompass analysis at both individual and organizational level, in order to truly capture the nature of outset U-I relationships, particularly when numerous formal and informal interactions are in place.

The successful execution of outset activities (either with or without previous ties) promotes the advance to low-risk activities, such as laboratorial service provision and engaged buyer-seller relationships. Other types of activities could be included in this stage, but the interviewees did not mention them. It is relevant to notice that these activities are not limited to strict transactions bound to terminate at some point in time, but instead represent an initial interplay that might allow future higher levels of collaboration. At this point, partners learn about each other's work and conduct and assess the extent to which their future interests in this relationship might be compatible with their partner's interests. A successful combination of interests generates "shared interests" that can be leveraged, along with trust and commitment, to lower the perception of risk and opportunism. This allows proceeding to higher levels of cooperation where more resources become available to the partnership, as presented in the findings underlying *P3* and *P4*. In the second level of cooperation represented in Figure 1, the activities described in the findings (shorter term theses that may lead to faster publications) tended to benefit academics more immediately. The industry interviewees concurred. The industry can only benefit from these activities if the results within the deliverables are beneficial to their commercial activity. As such, an asymmetry exists in the involvement of actors at this level, similar to asymmetries in B2B links involving actors of different dimensions (Blomqvist *et al.*, 2005). Academics are more engaged in the activities at this level because they value deliverables *per se*, while industry parties can only gain if the deliverables can be converted to commercial advantage. In Figure 1 the level of engagement of each type of participant is not represented, just their relational interdependence.

At the highest level of U-I collaboration, formal R&D cooperation activities are added, leading to joint R&D projects, shared PhD students and co-authored papers or patents, or even the creation of spin-offs. When the relationship progresses to this highest level of interdependence in the cooperation continuum (right-hand side of Figure 1), strong actor bonds are observed and several value-added activities are performed, many of which are extensively described in the literature (D'Este and Patel, 2007; Bekkers and Freitas, 2008). At this level, trust assumes a crucial role in relationship building. Specifically, it represents the basis for interpersonal interaction with U-I partners being more willing to engage in exchanges and cooperative activities when levels of trust are high (Ring and van de Ven, 1992; Powell, 1996; Morgan and Hunt, 1994). According to the interviewees, only a fraction of all cooperation experiences ever reach this high level of interdependence. Nevertheless, most of the

literature on U-I driven innovation only addresses this last, less frequent but very successful level of cooperation. This bias does not allow understanding how this level is reached, and more importantly, why it may not be reached. As depicted in Figure 1, the levels of lower interdependence are very rich in interaction and partner matching, and are indispensable to reach the highest level. Also, the lower levels have relational challenges that may not be as frequent in higher levels but that significantly impact on continuity, such as opportunism, distrust, and inefficient communication, among others (Seppänen and Blomqvist, 2006; Achrol and Gundlach, 1999; Santoro and Saparito, 2003). Finally, by studying the whole cooperation continuum it is possible to identify key points for managing the relationship and pinpoint the attributes or events that lead to a successful or unsuccessful relationship, in view of future application in the establishment of more successful networks.

To conclude, this research contributed to a better understanding of the activities and relational resources involved at the outset of successful R&D cooperation activities. Companies' motivations at the beginning of U-I links are strongly organizational, while academics are mostly motivated at a personal level (*P1*). These interactions grow in a cooperation continuum from low-risk, low-investment activities, such as service provision and buyer-seller exchanges. As the relationship grows, actors consider themselves partners instead of clients and more complex tasks are added to the existing link, namely the development of students' dissertations and shared R&D activities (*P2*). All these activities are supported by relational resources, explained by the IMP and social capital theories, that are crucial for the relationship, i.e. shared interests, trust and commitment. This work shows that shared interests are present at the outset of U-I links and grow alongside the building of the relationship, leading partners to increasingly share resources and complex activities, such as applying joint proposals for funding, submitting patents or launching a spin-off (*P3*). Finally, trust and commitment were not found to be ubiquitous at the outset of U-I links, but rather at later stages of cooperation, as a result of developed interdependence between partners (*P4*).

Theoretical contributions
Over the last decades, R&D cooperation studies have mostly focused on understanding the role of universities (and other knowledge producers) and companies in technology/knowledge transfer (Bekkers and Freitas, 2008; Agrawal, 2001), along with the impacts towards regional and national innovation systems (Fritsch and Kauffeld-Monz, 2010; Ozcan and Islam, 2014). However, a new approach addresses the social and relational side of innovation, focusing on the relationship between actors and its impact on innovation (Landry *et al.*, 2002). Instead of justifying this as a function of R&D performance indicators, the actors' diversity and their relationships are recognized as *ex ante* drivers of innovation (Pérez-Luño *et al.*, 2011). The present work followed this trend through a qualitative approach, and showed how activities and relational and non-relational resources change throughout the whole cooperation continuum between U-I actors. This was done within the framework of the Portuguese biological sciences scientific community. The results of this work focus on efficacy of U-I relationships at their starting up level, at the source of their first interaction, when crucial interactions may allow or impede further developments. As such, this work presents a new direction of research towards understanding the lower but indispensable levels of the cooperation continuum. Throughout the continuum, and to the extent of our knowledge, the concrete roles of trust, commitment and shared interests towards U-I actors interdependence are yet to be fully understood, reason why the current study

enriched our understanding of this phenomenon. Specifically, understanding the role and evolution of each relational resource (trust, commitment and shared interests) in the developing U-I link, should help explain to what extent each one contributes to more interdependent and valuable relationships.

From a theoretical perspective, the activities at the outset of U-I relationships seem to be distinct from previous accounts of B2B marketing literature. In particular, the IMP research has a substantial focus on inter-organizational networks and bonds between actors at the institutional level. According to the present results, relationships in the U-I context are simultaneously important at the organizational and individual level, from the outset onwards. This limits the capacity of the IMP approach to capture the whole range of data underlying the establishment of links between researchers. The combination of the social capital concepts, as proposed by Batt (2008), proved to be very useful in the present paper in a sense that it enabled a broad understanding on the outset of U-I links. The strength and relative importance of the interpersonal and inter-organizational ties towards the success of shared activities were not compared in this study, however, they are expected to have different contributions to cooperation, given that university interviewees considered the role of their interpersonal networks and benefits more important. The present work should positively contribute to the IMP group stream by extending the scope of resources frequently under study.

As previously reported in the literature, each academic researcher promotes their own interpersonal network, despite organizational boundaries, and there is significant value to such an approach (Beaudry and Kananian, 2013; Baba *et al.*, 2009). Interpersonal ties with external partners, as opposed to the inter-organizational level, constitute an important network resource (Gulati, 2007), and an important form of social capital. Accordingly, this study demonstrates that social capital reinforces the value derived from each network, based on trustful relationships among actors. Consistent with previous studies, trust is the basis for knowledge-related interactions, such as exchange, integration, cooperative problem-solving and constructive dialogue (Morgan and Hunt, 1994; Powell, 1996). Previous research on inter-organizational networks also identified the need for new relational models that may contribute to explain the processes and contents of relationships (Håkansson and Ford, 2002; Håkansson and Snehota, 1995). While this work did not propose a new model, it discussed relevant aspects that should positively contribute to advance the ARA model in the framework of U-I links: the different levels of analysis (individual vs organizational); the relational disparities between early and established ties; and the interplay between low- and high-investment activities underlying researchers' relationships.

Managerial contributions
Universities and research institutions that want to promote greater integration and cooperation with industrial partners need to focus on the researchers that are motivated for engaging in U-I links. From the perspective of interviewees, Portuguese universities do not yet have the capacity to systematically foster these relationships, and the current scenario mostly consists of casual meetings between parties that eventually lead to cooperation, without the academic institution being a key active member in the relational development. Typically, the involved researchers are in charge of defining the strategy and negotiations of contacts and ongoing activities, while university officers are mostly involved in drafting contracts or other documents required for the R&D cooperation agreements. As shown in this study, the relationship starts much earlier and the university should manage it from the outset, not just during

1the late stages of knowledge sharing and cooperation. The challenges to initiate a successful cooperation continuum are amplified at the outset of relationships, when distrust seems to be most significant. Overcoming this natural mutual suspicion, connected to the perception of a partner's trustworthiness, should promote relationships and turn easier the subsequent more engaged levels of the cooperation.

On top of all major actions, universities, through their technology transfer officers (TTOs), should develop and implement mechanisms that motivate all partners to participate in collective actions. Specifically, TTOs should be actively engaged in promoting networking activities and informal meetings that could spark the cooperation, even if this only goes as far as mutual service provision. Additionally, universities have to develop the capacity to communicate their researchers skills in a language that companies value and understand, acting as facilitators of the cooperation (Lundberg and Andresen, 2012). To implement/improve these strategies is particularly important in view of the decreasing national and European scientific funding mentioned by RCDs and described in the literature (European University Association, 2012). Moreover, less R&D cooperation will derive from skipping significant lower engagement parts of the relational development, as partners may not be prepared to deal with the more demanding activities of the higher levels of cooperation. For example, given the importance of the funding aimed at joint R&D initiatives of European consortia, understanding and influencing partners' initial interactions seems key to promote functional and successful cooperating networks.

Limitations and future research
Focusing the study on the Portuguese biological sciences R&D community revealed important findings. Assuming that cooperation relies mainly on interactive and social processes, the geographical concentration of actors in a relatively small territory should facilitate the process of learning-by-interacting (Gertler and Levitte, 2005). Concurrently, studying actors within the same location may be beneficial as they are under the influence of the same socio-cultural, economic and political constraints. On the other hand, the results may not be generalizable to other regions within the EU, which configures a limitation *per se*.

Another limitation could come from the interviewees' perspective in which both successful and unsuccessful experiences have implications in shaping partners' expectations and motivations at the outset of new relationships. However, this study focused mostly on successful cooperation ventures, possibly generating a bias towards positive findings and conclusions. Future research on unsuccessful experiences is particularly adequate to understand the interactions at the lower levels of the cooperation continuum, where there is likely more opportunity to improve relationships success rates.

Despite the use of the concepts within the ARA model and social capital, this study was designed in a way that did not allow exploring the structure of interviewees' network. The existing connections between academics in the same research centre, and between universities in similar research domains, were not explored. Interviews focused on extensive details of one or two cooperation experiences with business partners. Although the interplay between personal and organizational networks was not foreseen before data collection, it should be regarded as an opportunity for this research area, as this work highlighted the role of interpersonal ties to promote formal U-I links. Moreover, considering how U-I organizations and researchers differ in motivations and objectives (López-Martínez *et al.*, 1994), it could be beneficial for future studies to consider an additional dimension of social capital in order to model these

interactions. Future researchers may wish to consider examining the direct and indirect effects of different social capital dimensions along different stages of the cooperative relationships (Tsai and Ghoshal, 1998; Nahapiet and Ghoshal, 1998). Specifically, a cognitive dimension could encompass the shared languages and terminology that enable effective U-I communication; and the shared vision of partners towards cooperation opportunities of mutual value (Tsai and Ghoshal, 1998; Nahapiet and Ghoshal, 1998). Finally, in our view, the complex interaction framework under which U-I links develop, further justifies the use of Social Network Analysis as a method to model different types and levels of relationships (Wasserman and Faust, 1994).

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