Universities–Industry Collaboration: A Systematic Review

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Universities–industry collaboration: A systematic review

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Inter-organizational relationships;
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Summary The collaboration between universities and the industry is increasingly perceived as a vehicle to enhance innovation through knowledge exchange. This is evident by a significant increase in studies that investigate the topic from different perspectives. However, this body of knowledge is still described as fragmented and lacks efficient comprehensive view. To address this gap, we employed a systematic procedure to review the literature on universities–industry collaboration (UIC). The review resulted in identifying five key aspects, which underpinned the theory of UIC. We integrate these key aspects into an overarching process framework, which together with the review, provide a substantial contribution by creating an integrated analysis of the state of literature concerning this phenomenon. Several research avenues are reported as distilled from the analysis.

Introduction

Universities–industry collaboration (UIC) refers to the interaction between any parts of the higher educational system and industry aiming mainly to encourage knowledge and technology exchange[1] (Bekkers & Bodas Freitas, 2008; Siegel, Waldman, & Link, 2003). UIC have had a long history (Bower, 1993; Oliver, 2004), as one means of building organizations' knowledge stock (Cricelli & Grimaldi, 2010). Of late, there has been a substantial increase in these collaborations in several nations including: the United States (e.g. Lehrer, Nell, & Garber, 2009), Japan (e.g. Woolgar, 2007), Singapore (e.g. Lee & Win, 2004), and European Union Countries (e.g. Barrett, Austin, & Mccarthy, 2000; Gertner, Roberts, & Charles, 2011; Powers, 2003). This increase has been attributed to a combination of pressures on both industry and universities (Giuliani & Arza, 2009; Meyer-Krahmer & Schmoch, 1998). For industry, pressures have included rapid technological change, shorter product life cycles and intense global competition that have radically transformed the current competitive environment for most firms (Bettis & Hitt, 1995; Wright, Clarysseb, Lockett, & Knockaertd, 2008). With regards to universities, pressures have included the growth in new knowledge and the challenge of rising costs and funding

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[1] Similar to other studies (e.g. Agrawal, 2001; Bekkers & Bodas Freitas, 2008), we use the terms 'technology' and 'knowledge' interchangeably.

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problems, which have exerted enormous resource burdens on universities to seek relationships with firms to enable them to remain at the leading edge in all subject areas (Hagen, 2002). In addition, there is a mounting societal pressure on universities for them to be seen as engines for economic growth and less as fulfilling the broader social remit (i.e. education and generating knowledge) they have had in the past (Blumenthal, 2003; Philbin, 2008). These pressures on both parties have led to an increasing stimulus for developing UICs that aim to enhance innovation and economic competitiveness at institutional levels (e.g. countries and sectors) through knowledge exchange between academic and commercial domains (Perkmann et al., 2013). Moreover, UIC has been widely perceived as a promising tool for enhancing organizational capacity in open innovation — where an organization employs external networks in developing innovation and knowledge (Dess & Shaw, 2001), as a complementary option to traditional internal R&D (Harvey & Tether, 2003).

Whilst a surge in UIC-related research can be realized, the extant literature is still relatively fragmented and lacks a comprehensive view (Bovaird, 2007; Perkmann et al., 2013). The aim of this study, therefore, is to provide a greater understanding of UIC for knowledge and technology exchange by examining and critically integrating the main aspects of this inter-organizational relationship through a systematic review. Specifically, our review process was guided by a principle research question: What are the main themes of UIC? We consolidate our findings by bringing together a number of separately conducted studies, sometimes with conflicting findings, and synthesizing their results in specific areas. Specifically, we contribute to the literature and practice in three different ways. First, we present a comprehensive systemic review on the UIC state of knowledge. This allowed us to identify five key aspects that dominate the UIC literature. Such a wide coverage in one study does not appear to have been previously reported in the literature, as most studies have concentrated on only one or two of these areas at a time, for instance proposing a typology for UIC (Dess & Shaw, 2001), identifying firm/university characteristics as involved in UIC (Agrawal, 2001), and addressing UIC antecedences and consequences (Perkmann et al., 2013). In addition, our research, in contrast to other studies (e.g. Philbin, 2008), focuses on UIC in general and not only on 'contract research' UIC. The former is a wider perspective for UIC as it implies a bi-directional exchange of knowledge, where the latter normally includes one directional knowledge export from universities and thus primarily focuses on the commercialization of technology (Meyer-Krahmer & Schmoch, 1998). Moreover, this study is distinct from previous studies in the sense that it has an equal focus on both universities and industry perspectives. Relying on information gathered from one perspective would normally jeopardize the validity of results and limit the chance to reach a comprehensive view regarding UIC (Santoro & Chakrabarti, 2002). Second, we synthesize our findings in a form of conceptual process framework that links the five dominating themes in the UIC literature. Importantly, the framework was used to outline potential gaps in our knowledge about this phenomenon and suggest several avenues for future research. Third, the study is practice-relevant. We provide further insights into the various ways in which technology exchange between universities and industry may occur (i.e. the developed process framework) so that partnered organizations could devote more attention to the activities involved.

The rest of this paper is organized as follows. The next section provides the methodological approach for the systematic review. Then we summarize the outcomes of the review in five key areas, which we refer to as UIC main themes: forms, motivations, formation and activities, enablers and inhibitors, and outcomes. The fourth section discusses critically the existing theories underpinning UIC, and builds upon the review outcome to propose a conceptual process framework for UIC. Conclusion and new research directions are presented in the last section.

Methodological approach for the systematic literature review

Although systematic literature reviews were first pioneered in medical research (Black, 2001), they are increasingly being used in the social sciences (Burrows, 2000) and the management field (Pittaway & Cope, 2007; Shwom, 2014). A systematic review is a study that seeks to answer a clearly formulated question by finding, describing and evaluating evidence from all published research on topic(s) relates to that question within a specific set of boundaries (Eriksson, 2013). Importantly, it differs from traditional narrative reviews by adopting a reliable and rigor process that reduces subjective bias and lowers the risk of overlooking relevant literature. A systematic review may also be differentiated from traditional literature reviews in the sense that in traditional reviews there is often no attempt to seek generalizations or cumulative knowledge of what is reviewed (Davies, 2000). Rather, the task is to identify the range and diversity of the available literature, much of which might be inconclusive, and to find a gap which new research might fill (Tranfield, Denyer, & Smart, 2003). Davies (2000) describes such reviews as opportunistic, selective, haphazard, lacking systematic and exhaustive search of all the relevant literature.

For this study, our main objective was to establish what is known about the key aspects of UIC, and to find out how these aspects may be related so a conceptual development in UIC literature can be achieved. This objective was influenced by our observation that there is a considerable amount of research on UIC which has resulted in extensive literature emphasizing the mechanisms (including initial conditions) that have been developed for the interaction between universities and industry, as well as the outcomes of such collaborations. Therefore, a systematic review of the literature accumulated in this area was deemed necessary to assess the current knowledge and collate scattered findings to present them in a way that is more relevant, reliable and provides collective insights and guidance to meet the needs of academics, practitioners and decision-makers.

Guided by this objective, we followed largely the method suggested by Tranfield et al. (2003) to carry out the review. We started by identifying all relevant articles produced from 1990 to 2014. Research literature prior to 1990 was not considered because co-operation between universities and

industry was taken to be relatively less important during that period (Howells & Nedeva, 2003; Poyago-Theotoky, Beath, & Siegel, 2002). Besides, since the phenomenon of UIC is an evolving one (Blumenthal, 2003; Newberg & Dunn, 2002), the cumulative nature of the field means that the danger of omitting earlier major contributions will be mitigated by recent papers that build on the findings of earlier ones. The search strategy covered only peer-reviewed journal articles published in electronic database, because they have more validity and are likely to cover the main contribution in the field (Payne, Moore, Griffis, & Autry, 2011; Perkmann, Neely, & Walsh, 2011). A search of the following electronic databases for titles and abstracts of potentially relevant studies was conducted: ABI Global, Applied Social Sciences Index and Abstracts, Elsevier (Science Direct), International Bibliography of the Social Sciences, Ingenta, NetEc, and Social Science Citation Index (Web of Science). These particular databases have been selected because they provide a wide coverage of the literature in the area under study. There was no restriction on country of origin or on source sector (e.g. academic, government, policy, etc.) or the type of industry. Only published work in the English language was included. We searched these databases to identify initial relevant studies using specific combinations of terms, including: 'university' OR 'academia' OR 'higher educational institution' AND 'business' OR 'industry' OR 'firm' AND one of the following: 'alliance', 'bridge', 'collaboration', 'cooperation', 'exploitation', 'innovation', 'inter-organizational relationship', 'interaction', 'link', 'partnership', 'research and development', 'relationship', 'technology transfer', 'knowledge transfer', and 'scheme'. Although using these terms was expected to initially generate a large number of studies, this was necessary to ensure that all potentially relevant studies have been considered. This procedure yielded more than 1500 results, which was considered as our initial sample.

Given that the main question of the review is to prescribe comprehensively the key aspects of UIC, we read the title and abstracts (and the introduction in a few cases) of each article to identify its main objectives and contributions (Payne et al., 2011; Shwom, 2014). This step was essential to set the inclusion/exclusion criteria we applied later to select our final sample. Several initial coding themes have emerged inductively. After iterative discussions within the research team, five dominating aspects of UIC have been agreed as: forms, motivations, formation and operationalization, enablers and inhibitors, and outcomes. Drawing on these aspects, we set six questions which to be used as the criteria for inclusion and exclusion of studies in the review to determine the final sample. These questions are outlined below:

1. Does the study address the collaboration between Universities and Industry for technology exchange as a main inquiry?
2. Does the study address UIC motivations?
3. Does the study examine UIC forms?
4. Does the study provide information on the formation and operationalization of UIC?
5. Does the study include factors that facilitate or inhibit UIC?
6. Does the study mention the outcomes (benefits or drawbacks) of UIC?

A study was included in the final review if the answer to question 1 and any one of the following questions (2, 3, 4, 5, or 6) is positive (i.e. Yes).

The screening process involved, in addition to the above questions, quality assessment check. Quality assessment was undertaken with the view of discriminating between the better and lesser quality studies in the available evidence base. Quality assessment was necessary to appraise a study's internal validity and the degree to which its design, conduct and analysis have minimized biases or errors. This check was determined by the content of each study following a similar approach suggested by Tranfield et al. (2003). However, the assessment was aided by Farrington's methodological quality scale (Farrington, 2003). The author proposes five criteria to assess the methodological quality of evaluation studies, including: internal Validity (or the degree to which the results of a study approximate the truth), (2) Descriptive validity (refers to the factual accuracy of the account as reported by the researchers), (3) Statistical conclusion validity (concerned with whether the presumed cause and the presumed effect are related), (4) Construct validity (refers to the adequacy of the operational definitions, and measurement of theoretical constructs that underlie the intervention), and (5) External validity (in the case of quantitative studies) and Representativeness/Triangulation (in the case of qualitative analysis). Each of the studies was assessed and classified as ''Quality Acceptable'' or ''Quality Unacceptable'', whereby only studies tagged as ''Quality Acceptable'' were included in the review. By employing inclusion and exclusion criteria, as well as quality checks, the final sample comprised 109, Appendix A holds a full record of these studies.

Following this stage, we employed techniques from the field of qualitative data analysis, mainly matrix method and tabulation technique (Miles & Huberman, 2008), on the full texts of the final selected articles. This aimed to compile evidence and information that primarily relate to the five identified key aspects. We started the coding by reading through each paper, word-by word, to detect parts in the text and attach them to relevant primary themes (i.e. the key aspects). The next task was to review the content of each theme, which has been produced as a separate (or a summary) document for each of the key themes. Then we moved to the second and third levels of coding by clustering relevant chunks of information together under specific titles, which latter constitute the sub-themes under each of the key themes. In addition, careful attention has been paid at this stage at examining and highlighting divergence and convergence between the different paper, and sought explanations for any inconsistencies. This aimed to better understand the nature of these key themes and their relevance to the UIC subject.

Despite the proven strength of the systematic review procedure in terms of transparency and openness to critique, in comparison to traditional narrative review methods, it has some limitations (Hakala, 2011). The first issue relates to the study's boundaries. The current research reports and discusses articles that have been included in academic journals during the period 1990 and 2014. This indicates the potential of some relevant studies (e.g. book chapters) to be excluded

from the review. Nonetheless, this is an acceptable practice in systematic review (Pittaway & Cope, 2007), as all important contributions in a given research field would usually appear continuously in subsequent journal papers. The second limitation concerns the selection of keywords applied to control in the inclusion criteria of the papers. However, and to mitigate the consequences of this issue, a careful approach has been followed in the inspection process that incorporates three steps: title, abstract, and full text. Importantly, this would ensure that all relevant studies have been consulted.

Findings

In this section, we report the findings from the systematic review in a form of answer to a specific question. Each question concerns one of the five dominating themes as emerged from the analysis.

What are the organizational forms of UIC?

The forms of UIC mostly pursued in practice and discussed in the literature are: Joint Ventures, Networks, Consortia, and Alliances (Barringer & Harrison, 2000), and these different forms vary by the degree to which the participants are linked. However, authors do not agree on the definitions and distinctions of the various forms of UIC (Bruneel, D'esteb, & Salter, 2010).

The above points were consistent with the findings from the review. While UIC appeared to encompass all of the forms universtires and indsurt relationship, a variety of other additional forms were identified (see Table 1), which indicates that the possibilities for interaction for UIC are relatively wide (Shenhar, 1993). It was also found that different researchers presented different typologies or taxonomies of the relationships. For example, Chen (1994) classified the forms of UIC for technology exchange according to the duration of the relationship and the technology flow. Santoro and Gopalakrishnan (2000), on the other hand suggest four classifications for UICs, including: (1) research support (i.e. Endowment/Trust Fund), (2) cooperative research (i.e. institutional agreements, group arrangements, institutional facilities, informal Intentions), (3) knowledge transfer (i.e. hiring of recent graduates, personal interactions, institutional programs, cooperative education) and (4) technology transfer (i.e. product development and commercialization activities through university research centers).

The review, therefore, confirmed Blackman and Seagal's (1991) view that the task of creating a typology that shows all the possible links that could occur between universities and industry is an extremely difficult one. However, the framework proposed by Bonarccorsi and Piccaluga (1994) was found to be relatively broad in scope and considered suitable for adoption for this research. The framework consisted of six main categories as presented in Table 1, namely: Personal Informal Relationships, Personal Relationships, Third Party, Formal Targeted Agreements, Formal Non-targeted Agreements and Creation of Focused Structures. However, the composition of each of the categories in the original classification by Bonarccorsi and Piccaluga (1994) has been extended to reflect the additional information from the systematic review as shown in Table 1. It is worth noting that the six groups exhibit an increasing level of organizational involvement, which can be briefly analyzed in terms of three dimensions: (a) organizational resource involvement from the university; (b) length of the agreement; and (c) degree of formalization. For the first dimension, there is no organizational resource involvement by the university if the firm's contact with the university is with an academic as an individual without any agreement signed with the university. Beyond this, university's resource involvement increases from Formal Personal Relationship down the categories to Focused Structures, where the entire university is involved in specific structures to collaborate with industry. The length of the agreement between universities and firms, as the second dimension, could vary from short (though renewable) in the case of Personal Formal Relationships, to long in the case of specific or Focused Structures. The exception is the case of relationships between universities and industries organized by a Third Party, which could have a long length of the agreement if the relationship turns into a more stable one.

On the formalization of the agreement, the third dimension, this is low or completely absent for Personal Informal Relationships. For Personal Formal Relationships and Third Parties, formalization of the agreement could exist or not exist, while in the remaining groups the relations are formalized (Bonarccorsi & Piccaluga, 1994). Nonetheless, Ring and van de Ven (1994) note that the issue of formalization is very important because of the argument that increasing formalization and monitoring of the relationship in a UIC could lead to conflict and distrust among the parties in their attempt to maintain the autonomy of their organizations in the face of increasing interdependence (Ring & Van De Ven, 1994; Santoro & Gopalakrishnan, 2000).

What are the motivations for UIC?

To investigate the motives for UIC, we draw on the work of Oliver (1990), which posited six critical contingencies as generalizable determinants of inter-organizational relationships. These contingencies can be perceived as underpinning organizations' interest to interact with one another. Oliver noted that although each determinant alone was sufficient to cause a relationship formation, the determinants might also interact or occur concurrently when organizations decide to form an inter-organizational relationship. Two delimiting assumptions underlie these determinants according to Oliver. First, organizations are assumed to make deliberate decisions to establish an IOR for explicitly formulated purposes. Second, an organizational perspective (top-management) approach is assumed, even though the determinants may also explain lower and sub-unit reasons (Oliver, 1990). On the other hand, the six contingencies seemed to correlate very well with strategy motives for alliances (Kyrgidou & Spyropoulou, 2013). Moreover, and from the systematic review, the motivations for universities and industry engaged in UICs were found to align closely with the six critical contingencies or determinants identified by Oliver (1990). These contingencies, therefore, were used to categorize the motivations for UICs identified from the studies. Although some of the motivations identified could belong to more than one determinant, they have been placed under the determinant

Table 1 Organizational forms of UIC.

Personal Informal Relationships	— Academic spin-offs — Individual consultancy (paid for or free) — Information exchange forums — Collegial interchange, conference, and publications — *Joint or individual lectures* — *Personal contact with university academic staff or industrial staff* — *Co-locational arrangement*
Personal Formal Relationships	— Student internships and sandwich courses — *Students' involvement in industrial projects* — Scholarships, Studentships, Fellowships and postgraduate linkages — *Joint supervision of PhDs and Masters theses* — Exchange programmes (e.g. secondment) — Sabbaticals periods for professors — *Hiring of graduate students* — *Employment of relevant scientists by industry* — *Use of university or industrial facility* (e.g., *lab*, *database*, etc.)
Third Party	— Institutional consultancy (university companies including Faculty Consulting) — Liaison offices (in universities or industry) — *General Assistance Units (including technology transfer organizations)* — Government Agencies (including regional technology transfer networks) — Industrial associations (functioning as brokers) — *Technological Brokerage Companies*
Formal Targeted Agreements	— Contract research (including technical services contract) — *Patenting and Licensing Agreements (licensing of intellectual property rights)* — Cooperative research projects — *Equity holding in companies by universities or faculty members* — Exchange of research materials or Joint curriculum development: — *Joint research programmes* (*including Joint venture research project with a university as a research partner or Joint venture research project with a university as a subcontractor*) — Training Programmes for employees
Formal Non-Targeted Agreements	— Broad agreements for U-I collaborations — *Endowed Chairs and Advisory Boards* — *Funding of university posts* — *Industrially sponsored R&D in university departments* — Research grant, gifts, endowment, trusts donations (financial or equipment), general or directed to specific departments or academics
Focused Structures	— Association contracts — Innovation/incubation centers — Research, science and technology parks — University—Industry Consortia — University—Industry research cooperative research centers — *Subsidiary ownerships* — Mergers

The *italic* indicates new organizational forms as identified from the review.

considered to be the most appropriate. Also, since the motivations for universities to enter into UICs are different from those for industry in some respects, the motivations for the two organizations are discussed separately.

Universities perspective

As informed from the analysis, the motivations for universities to enter into relationships with industry are summarized in Table 2. However, none of the motivations identified for universities could be categorized under the determinant of asymmetry, which suggests that universities are not influenced to enter into relationships with Industry to exercise power or control over industry or its resources.

Necessity. Against a background of increasing international competition and rapid technological change, governments are actively encouraging collaborations between universities and industry as a means of improving innovation efficiency and thereby enhance wealth creation (Barnes, Pashby, & Gibbons, 2002). According to Hall, Link, and Scott (2001)

Table 2 Motivations for universities and industry: a comparison.

Universities		Industry
Necessity	— Responsiveness to government policy — Strategic institutional policy	— Responsiveness to government initiatives/policy — Strategic Institutional policy
Reciprocity	— Access complementary expertise, state-of-the-art equipment and facilities — Employment opportunities for university graduates	— Access to students for summer internship or hiring — Hiring of faculty members
Efficiency	— Access funding for research (Government grant for research & Industrial funding for research assistance, lab equipment, etc.) — Business opportunity, e.g. exploitation of research capabilities and results or deployment of IPR to obtain patents — Personal financial gain for academics	— Commercialize university-based technologies for financial gain — Benefit financially from serendipitous research results — Cost savings (easier and cheaper than to obtain a license to exploit foreign technology) — National incentives for developing such relations such as tax exemptions and grants — Enhance the technological capacity and economic competitiveness of firms — Shortening product life cycle — Human capital development
Stability	— Shift in knowledge based economy (growth in new knowledge) — Discover new knowledge/test application of theory — Obtain better insights into curricula development — Expose students and faculty to practical problems/ applied technologies — Publication of papers	— Shift in knowledge based economy (growth in new knowledge) — Business growth — Access new knowledge, cutting-edge technology, state-of-the art expertise/research facilities and complementary know-how — Multidisciplinary character of leading edge technologies — Access to research networks or pre-cursor to other collaborations — Solutions to specific problems — Subcontract R&D (for example due to lack of in-house R&D) — Risk reduction or sharing
Legitimacy	— Societal pressure — Service to the industrial community/society — Promote innovation (through technology exchange) — Contribute to regional or national economy — Academics' quest for recognition or achieve eminence	— Enhancement of corporate image
Asymmetry	— NA	— Maintain control over proprietary technology

and López-Martínez, Medellín, Scanlon, and Solleiro (1994), an important issue for government policy makers and those concerned with research budgets (such as the Research Councils) is the functioning of the interface between universities and industry to ensure that exploitable research transfer to industry quickly and successfully to contribute to the growth and well-being of the economy. Hence universities are increasingly turning their attention to encouraging UIC in response to government policy and also as an institutional strategic policy (Howells, Nevada, & Georghiou, 1998; Perkmann, King, & Pavelin, 2011a).

Reciprocity. Sherwood, Butts, and Kacar (2004) have argued that universities offer extensive access to a wide variety of research expertise and research infrastructure, whiles industry offers extensive access to a wide range of expertise in product development/commercialization, market knowledge (Sherwood et al., 2004) and employment opportunities for universities graduates (Lee & Win, 2004; Santoro & Betts, 2002). Therefore, universities can be motivated to build relationships with industry to take advantage of these strengths for mutual advantage.

Efficiency. While Government grants promote new UIC initiatives (Harman & Sherwell, 2002), the increasing pressures on public sources of finance for universities have provided a strong incentive for universities to also seek alternative potential sources of revenue for basic research and equipment through means such as commercialization of faculty research and the exploitation of intellectual property rights or licensing of patents, in order to reduce their dependence on the public purse (Logar, Ponzurick, Spears, & France,

2001). Blumenthal (2003) and Santoro and Gopalakrishnan (2001) also report that relationships with industry are also appealing to universities because industry funding usually involves less bureaucratic red tape than public funding. Other researchers like Siegel, Waldman, Atwater, and Link (2004) have also stated that faculty members may be motivated by personal financial gain to enter into relationships with industry.

Stability. Collaboration theory, in general, prescribes inter-organizational relationship as a strategy that can be adopted when environment becomes seriously instable and unpredictable (Boddy, Macbeth, & Wagner, 2000; Gray & Wood, 1991). According to Oliver (1990), organizations are motivated by the stability contingency to enter into collaboration in order to respond to environmental uncertainty to achieve predictability and dependability. Motivations related to this contingency identified from the review included the shift to today's knowledge-based economy that has brought about a shift in UIC from sponsorship to partnership with on-going interaction as the main focus as noted by Jacob, Hellstrom, Adler, and Norrgren (2000). In particular, the growth in new knowledge has placed enormous resource pressures on individual universities, which has necessitated universities to respond by entering into alliances with industry in order to remain at the leading edge in all subject areas. According to Cyert and Goodman (1997), universities scientists typically view these links as providing fertile grounds for developing and testing theories, honing their skills, training and placing their students. Meyer-Krahmer and Schmoch (1998) and Santoro and Chakrabarti (2001) have also posited that universities collaborate with industry to expose academics and students to industrial environments, the most up-to-date insights from industrial research, instructional case studies and practical problems through projects. All of these contribute to curriculum development and improve the quality of teaching (Santoro & Gopalakrishnan, 2000). Furthermore, Harman and Sherwell (2002) suggest that an important incentive for universities to partner with industry is publication in journals, as producing accessed-publicly information would emphasize the original mission of universities in disseminating the knowledge (Newberg & Dunn, 2002).

Legitimacy. Another motivation for universities to enter into relationships with industry is an intrinsic desire to enhance the universities' prestige (Mora-Valentin, 2000). There is also a growing societal (political and public) pressure on universities to demonstrate greater social accountability, entrepreneurship, and overall economic relevance to society (Cohen, Florida, Randazzese, & Walsh, 1998) This pressure motivates universities to enter into forms of co-operation with industry through knowledge and technology exchange or diffusion (Siegel, Waldman, & Link, 2003), to enable them contribute to economic development (Blumenthal, 2003; Hagen, 2002). Siegel et al. (2004) have also observed that a primary motive of universities scientists is recognition within the industrial scientific community, which typically emanates from joint publications, presentations at prestigious conferences, and research grants. In addition, industry support assists faculty in conducting research that allows them to achieve academic eminence.

Industry perspective

On the part of industry, the motivations to enter into relationships with universities covered all of Oliver's six contingencies, and are presented in Table 2.

Necessity. Governments have been compelled by the global rapid changes in the competitive and technological environment to take actions to support research interactions between the two sectors as governments believe that universities could aid in economic regeneration (Mora-Valentin, 2000; Perkmann et al., 2013) if they disseminate their knowledge and expertise through industry linked partnerships. Therefore, various regional and national research programs have been initiated by governments (Caloghirou, Tsakanikas, & Vonortas, 2001) such as the UK Knowledge Transfer Partnerships. A condition for industry to benefit from most of these programs is for industry to collaborate with the universities (Howells et al., 1998).

Asymmetry. A motivation for industry to enter into UIC is to seek to commercialize universities-based technologies for financial gain (Siegel, Waldman, & Link, 2003). To be able to do so, many firms desire exclusive rights to the technologies that are generated. They are therefore concerned about maintaining control over the direction of universities research (Newberg & Dunn, 2002) as well as proprietary control over the technologies.

Reciprocity. Another motivation for industry to enter into UICs is to gain access to students for summer internships or hiring (Ankrah, Burgess, Grimshaw, & Shaw, 2013; Siegel, Waldman, & Link, 2003). Most UIC research programs target the hiring of the best students as a result of the interaction (Fellera, Ailesb, & Roessnerb, 2002). Faculty members or senior researchers can also be hired to consult during the time they are allowed to work outside of the universities (Perkmann, King, et al., 2011).

Efficiency. From the standpoint of efficiency, there are several motivations for industry to enter into UICs with universities. Cohen et al. (1998) report that universities and industry research can enhance firms' sales, R&D productivity, and patenting activity. Firms also partner with universities because of the possibility of benefiting financially from serendipitous results of research activity, innovative outputs, cost savings especially those relating to knowledge creation and exploitation (George, Zahra, & Wood, 2002), all of which could give a firm competitive advantage and improve its financial performance (Grant, 1996). Another motivation is governments' stimulation of research and development (R&D) and the growth of technology through the use of financial instruments like grants and tax credits as well as the creation of a legal environment supporting R&D (Barnes et al., 2002). In addition, human capital development, including continuing professional education (Santoro & Chakrabarti, 1999), access to cutting-edge technologies with multidisciplinary character and state-of-the art expertise/research facilities are also industry motives, as these help to mitigate the impact of current shorter product life cycles (PLC) and thereby enhance competitive advantage (Bonaccorsi & Piccaluga, 1994). Through UIC, a firm can get access to

a wellspring of new competitive technologies that render the distance between design and production relatively short (Santoro & Gopalakrishnan, 2001). This would enable recovering the development costs for a specific product quickly, since the agreements might involve downstream activities such as development and prototyping.

Stability. Similar to universities, the shift to today's knowledge-based economy is acknowledged as being a motivating factor for industry to enter into relationships with universities (Santoro & Betts, 2002). Pavitt (1988) concludes that academic research augments the capacity of businesses to solve specific complex problems. An increasing number of studies also demonstrate that UIC are an excellent way of creating and stimulating technology-based firms, particularly SMEs for business growth (Klofsten & Jones-Evans, 1996). The lack of in-house R&D by industry is also cited as a major motivator for industry collaboration with universities. López-Martínez et al. (1994) showed that the lack of in-house capacity by industry to carry out technological research was the most valued motivation for business executives. In the view Schartinger, Rammer, Fischer, and Fröhlich (2002), even for companies with R&D, collaboration is valued, as it reduces risk and stretches limited resources such as human and capital. Furthermore, access to research networks involving other universities and companies, as well as the potential of more complex collaborations in the form of consortia involving multiple firms, universities, and other collaborations are motivations for industry to enter into collaboration with universities (George et al., 2002).

Legitimacy. Siegel, Waldman, and Link (2003) have also pointed out that firms can often enhance their image and reputation by associating with a prominent institution. The relationships with established and reputable organizations such as leading research universities could enhance a company's legitimacy in the eyes of other powerful stakeholders (Hong & Su, 2013; Mian, 1997).

How are UIC formed and operationalized?

Several models are presented in the literature on the process of UICs formation (e.g. Tuten & Urban, 2001). One model, which is considered relevant for adaptation for UICs formation, is Mitsuhashi (2002) model for business-to-business alliance formation. Mitsuhashi defines alliance formation in five steps, beginning with the definition of the alliance opportunities and ending with making the deal. A modified version of Mitsuhashi's model is presented in Table 3 for UIC formation on the basis of the evidence adduced from the systematic review. The number of stages or steps that the formation of a particular organizational form of UIC would go through was found to depend on its degree of formality and complexity. The first two processes of Mitsuhashi's model (i.e. Defining Alliance Opportunities and Identifying Prospective Partners) have been merged into Stage 1 (Partnership Identification) in Table 3. The third process in Mitsuhashi's model (i.e. Making Contacts) has been maintained as Stage 2 (Make Contact). The fourth process in Mitsuhashi's model (i.e. Due Diligence) has been broken down into two stages in Table 3: Stage 3 (Partner Assessment and Selection) and Stage 4 (Partnership Negotiation). Finally, the last process

Table 3 UIC formation process.

Stages	Steps
Formation process	
Stage 1: Partnership Identification	– Establish the purpose – Obtain general knowledge of the capabilities of potential partners – Consider pre-existent relationships
Stage 2: Make Contact	– Identify prospective partners
Stage 3: Partner Assessment and Selection	– Objectively assess the strategic interests of the potential partners – Analyze actual versus professed capabilities of potential partners – Determine and organize the appropriate mix of partners – Choose the partners
Stage 4: Partnership Negotiation	– Define the partnership – Define and agree on the partnership's documented purpose or mission/vision – Determine the specific common goals/objectives for the particular effort – Define the organizational structure of the partnership – Define the management and administration of the partnership with clearly defined responsibilities – Agree on the plan – Specify the milestones – Identify the measures/indicators for success – Specify the interim and/or final deliverables
Stage 5: Agreement Signing	– Preparation and signing of collaboration agreement and/or intellectual property agreement

in Mitsuhashi's model (i.e. Making Deals) has been renamed in Table 3 as Agreement Signing, Stage 5.

Since collaborations must be initiated, the first step in the formation of a UIC is establishing the purpose of the partnership followed by finding a partner. Several criteria have been suggested for partner selection. However, Barnes et al. (2002) advise that whatever the criteria of partner selection is considered, every effort should be made to carry out an evaluation of prospective partners, as considerable benefits could be gained from that, since among other things, it ensures that the collaboration is specific to the particular UIC.

A criterion underscored in the literature as facilitating partner evaluation is pre-existing relationships. Several studies have found that the outcome of UICs would be better if the partners had previous cooperative experiences (e.g. Dill, 1990; Geisler, 1995). Culati and Gargiulo (1999) explain that pre-existing relationships between partners are important because with prior experience of relationships with a potential partner, trust may already exist between the organizations since inter-organizational trust is incrementally built as firms repeatedly interact and mutually adjust to the expectations, evolution and demands of prior alliances. Schartinger, Schibany, and Gassler (2001) agree and add that past collaborative experience is crucial because satisfaction with past interactions on a personal, technological and research level lowers individual and institutional barriers and renders UIC more likely. Peterson (1995) notes that it is also important during the formation stage to clearly define the management and administrative responsibilities of the UIC including financial accountability. In addition, Peterson suggests that a common organizational structure suitable for the partners and the partnership's objective should also be defined under the direction of an overall manager selected by the partners. Furthermore, equal participation by the members in the direction of the collaboration effort is important (Peterson, 1995). The project plan, which Buttrick (2000) has described as an important success factor plan, should be mutually agreed upon by the partners and the milestones should also be specified. Furthermore, Peterson (1995) also suggests that measures of success must be identified, interim and final deliverables specified, and all differences between the partners resolved to avoid conflicts in the course of the collaboration.

Having defined the relationship, it is necessary, depending on the formality and complexity of the UIC, to bind it with a legal contract (Kanter, 1994), although the role of commitment is essential here which is maintained not only by formal agreements, but also by informal commitment which is developed through friendship and reciprocal trust (Babaa, Shichijo, & Seditac, 2009). Peterson (1995) advises that the legal document, which for some UICs, would be the same as the intellectual property agreement, should specify all of the relationships and agreements among the partners, both during the specific research collaboration and beyond the end of the project, and it should be approved by all the partners.

Following the formation of the UIC, the relationship enters an operational phase (Sherwood et al., 2004), which can be characterized by a process of constant learning and evolution (Ritter & Gemünden, 2003) and where a number of factors facilitate or inhibit the relationship (these factors are presented next). However, in the operational phase several activities also take place between the organizations with the objective of achieving the goals of the UIC (Ritter & Gemünden, 2003). These activities and how they occur are summarized in Table 4.

Table 4 was constructed by identifying the relevant themes from the studies used for the systematic review and grouping the themes appropriately into the following six sub-headings: (1) Meetings & Networking; (2) Communication; (3) Training; (4) Personnel Mobility; (5) Employment and (6) Other Activities. The intensity of occurrence of the activities as well as how many of them would occur in a particular organizational form of UIC were found to depend on the formality and complexity of the relationship.

What are the factors that facilitate or inhibit the operation of UIC?

Several factors that either facilitate or inhibit the operation of UICs were found in almost all of the studies reviewed, which confirmed the finding by many researchers that the literature on the factors that facilitate or inhibit UIC is indeed abundant (Bruneel et al., 2010; Cricelli & Grimaldi, 2010). The factors were found, if correctly managed, to have a positive effect on the perceived success of knowledge and technology exchange. On the other hand, where the same factors were neglected or mismanaged, there tended to be a corresponding negative impact on the perceived success of knowledge and technology exchange. These factors are summarized in Table 5 under the following seven categories or sub-headings: (1) Capacity and Resources; (2) Legal Issues, Institutional Polices and Contractual Mechanisms; (3) Management and Organizational Issues; (4) Issues relating to the Technology; (5) Political Issues; (6) Social Issues; and (7) Other Issues. Table 5 was constructed by adopting the first two headings (i.e. Capacity and Resources and Legal Issues, Institutional Polices and Contractual Mechanisms) from Fairweather (1991), and creating the remaining five headings to suit the emerged sub-themes.

The variety of factors confirmed Barnes et al.'s (2002) view that the success of a collaborative project is governed by a complex interaction of factors as well as the cumulative result of negative and positive impacts from those factors. In addition, of the total number of the factors identified, there were more factors in the management and organizational category (45%) than in any one of the other categories, which agreed with Siegel, Waldman, and Link (2003) that organizational and managerial issues were critical factors that facilitate or inhibit such relationships between Universities and Industry.

What are the outcomes of UIC?

Similar to any other type of inter-organizational relationship, UIC has its own benefits and drawback for both parties. Regarding benefits, several studies (e.g. Geisler, 1995; Lee, 2000) have linked motivations to benefits subsequently realized in UIC. However, not all benefits could be signaled by the motivations listed previously. Therefore, the specific benefits identified from the studies are dealt with separately in this section. All realized benefits by universities and industry have been coded under three headings: (1) Economic

Table 4 Activities during UIC.

Activities	
Meetings & Networking	– Meetings (often in a formal way) – Conferences/Workshops/Seminars/Symposia/Forums – Expositions, Trade Shows/Fairs/Exhibitions – Informal social gatherings (e.g. U-I get-togethers, breakfast meetings) – Networking activities (the process of contacting and being contacted and maintaining these relationships/links)
Communication	– Communications by voice/mail/email/conference calls (formal or informal) – Publications or co-publications of research papers, reports, newsletters, booklets, bulletins, pamphlets
Training	– Tailored educational programmes for industrial personnel – Internships in company for students – Students' involvement in industrial projects – Joint supervision of Masters degree dissertations and PhD Thesis by academic and industry personnel – Industrial fellowships for students and faculty – Industry involvement in curriculum development
Personnel Mobility	– Exchange of personnel to work at one another's research facilities – Lectures by industry members at universities and vice versa
Employment	– Employment of university researchers in the business sector – Employment of graduates particularly those related to the project – Representation on Industry Boards or University Committees

Benefits (i.e. benefits that feed into the overall economy); (ii) Institutional Benefits (i.e. benefits derived by Universities and Industry); and (iii) Social Benefits (i.e. benefits that relate to communal activity or promote sociability), as in Table 6.

By contrast, several drawbacks have been identified in the literature, where some researchers argue that although the benefits of UIC clearly outweigh any dangers, it is important for both the universities and industry, particularly the universities, to recognize the possible drawbacks, so that protective action can be taken to put in place well-developed policies and administrative procedures (Harman & Sherwell, 2002) to mitigate against failure and ensure the success of the relationship. Importantly, the drawbacks have been classified into four categories considered to be apposite: (1) Deviation from Mission or Objective; (2) Quality Issues; (3) Conflicts; and (4) Risks. Table 6 integrates these drawbacks for both universities and industry. Interestingly, it was noticed that research on UIC pays more attention to universities than industry when addressing its potential drawbacks. This can be explained by considering universities motives to UIC. As uncovered by Table 2, access to research fund is found to be the most dominating UIC motive for universities in the literature. By being highly driven by economic motives, and drawing on the resource dependence theory (Pfeffer & Salancik, 1978), universities are likely to be in a vulnerable position since they have less power and control over the agreement, which is something common in cross-sector collaboration that incorporates the industry as a main party (Al-Tabbaa, Leach, & March, 2014). This vulnerable position is likely to be the source of many other drawbacks, for example pressure by the industry towards fast-track results or the risk of limiting the dissemination of knowledge produced by the UIC in compliance with industry request.

Discussion

The collaboration between universities and industry is largely seen as one approach to improve innovation in the economy by facilitating the flow and utilization of technology-related knowledge and experience across sectors (Inzelt, 2004; Perkmann, Neely, et al., 2011). Importantly, this collaboration has two distinct characteristics. First, UIC is an inter-organizational relationship instance that involves engagement between universities and organizations from the business sector to exchange tangible (e.g. fund, materials, and equipment) and intangible (e.g. technology and data) resources (Perkmann et al., 2013). Second, and similar to cross-sector collaboration (e.g. Kindred & Petrescu, 2014; Kivleniece & Quelin, 2012), partners typically have both individual (e.g. academic publishing for universities and technical problem solving for industry) and common objectives (e.g. create impact by providing solutions for society's problems) that drive their interest in collaboration. This reflects the strategic effect of collaboration whereby UIC is viewed as a rational process. Strategic effect occurs when organizations rationalize their inter-organizational relationships as a mean to acquire the resources they lack (Airto, 2001; Koka & Prescott, 2002). In other words, UIC is perceived as a rational process when it is primarily sought for pooling and exchange of resources of all kinds.

However, UIC (as one special form of inter-organizational relationship) can also be viewed as a process that seeks knowledge-creation, where new knowledge is created that

Table 5 Factors facilitate or impede UICs.

Main categories	The factors
Capacity and Resources	— Adequate resources (funding, human and facilities) — Incentive structures for university researchers — Recruitment and training of technology transfer staff — Capacity constraints of SMEs
Legal issues, and Contractual Mechanisms	— Inflexible university policies including intellectual property rights (IPR), patents, and licenses and contractual mechanisms — Treatment of confidential and proprietary information Moral responsibility versus legal restrictions (research on humans)
Management and Organization Issues	— Leadership/Top management commitment and support — Collaboration champion — Teamwork and flexibility to adapt — Communication — Mutual trust and commitment (and personal relationships) — Corporate stability — Project management — Organization culture (cultural differences between the world of academia and of industry) — Organization structure (university administrative structure and firm structure) — Firm size (size of organization) — Absorptive capacity — Skill and role of both university and industry boundary spanners — Human capital mobility/personnel exchange
Issues Relating to the Technology	— Nature of the technology/knowledge to be transferred (tacit or explicit; generic or specialized; academic rigor or industrial relevance)
Political Issues	— Policy/legislation/regulation to guide/support/encourage UIC (support such as tax credits, information networks and direct advisory assistance to industry)
Social Issues	Enhancement in reputation/prestige
Other Issues	— Low level of awareness of university research capabilities — Use of intermediary (third party) — Risk of research — Cross-sector differences/similarities — Geographic proximity

neither of partners have previously possessed (Hardy, Phillips, & Lawrence, 2003; Mowery, Oxley, & Silverman, 1996). In this regard, knowledge is perceived as a tacit context-related object, rather than an explicit resource that can be codified and exchanged between organizations, that is generated through an on-going social interaction between partners' actors during the lifetime of the collaboration (Powell, Koput, & Smith-Doerr, 1996). This implies that collaboration effectiveness, in terms of knowledge-creation, can be determined by the variety and intensity of organization's external ties (Huggins, Johnston, & Thompson, 2012; Nonaka, 1994; Simonin, 1997). Therefore, Powell et al. (1996) suggest that we should distinguish between knowledge-transfer and knowledge-creation when studying collaboration outcome. The former considers the inter-organizational relationship as a rational process that specifies in advance the goal of such relationship, as well as the size and scope of each organization's involvement. In the latter, the collaboration is deemed as an irrational, informal, and unstructured process where a relationship between two organizations evolves naturally due to unplanned and continuous interactions between actors from both organizations. Drawing on this discussion, it can be concluded that UIC can be viewed as either a rational (focuses on planned resource and knowledge transfer) or irrational (knowledge creation is located within the informal social interaction between organizations) process.

Nonetheless, as uncovered in our analysis (see the motivations section), it was evident that the view of UIC as a rational process is most prevailing in the UIC literature. This orientation might be explained by the procedure through which the collaboration is enacted, planned and operationalized. Typically, any UIC would pass through a lengthy scrutinizing process (by both partners) before an agreement can be formulated and signed (Bruneel et al., 2010). Two main issues entail such extensive evaluation and inspection. First, because of the economic pressure, the stakeholders of universities and companies maintain a high expectation that their organizations will demonstrate accountability and effectiveness in how resources are exploit when establishing inter-organizational links (Nahapiet & Ghoshal, 1998). For example, government and other funding bodies would expect universities to utilize UIC to address some society's social or economic problems (e.g. improve the employability of university graduates), whereas company's shareholders would

Table 6 UIC outcomes.

	Universities	Industry
Benefits		
Economic-related	— Source of revenue (both public and private) — Patents/IPRs/licensing income — Additional income or financial benefit to researchers — Create business opportunities — Contribution to local/regional economic development	— New products and/or processes — Improved products and/or processes — Patents, prototypes, generate IPRs, etc — More cost-effective than similar research in-house — Improved competitiveness — Access public grants — Promote economic growth/enhancement of wealth creation
Institutional-related	— Exposure of students and faculty to practical problems/new ideas and/or to state-of-the-art technology, with positive effects on the curriculum — Provide a ''test bed'' for feedback on research ideas, results/interpretations for the refinement of academic ideas/theories — Stimulate technological advancement and/or research activities in certain key areas — Acquisition of or access to up-to-date equipment — Training and employment opportunities for students — Build credibility and trust for the academic researcher among practitioners — Stimulate the development of spin-offs (or spin-off companies) — Provide opportunity for companies to influence and encourage the development of particular lines of university research — Joint publications with industry — Publication of papers by academics	— Improved innovative ability and capacity/ Keep up to date with major technological developments — Advance new technologies — Accelerates commercialization of technologies/Increases speed of innovation to market — No inter-firm conflicts of interest — Provide much needed legitimacy for industry products (e.g. software programme) — Access to new knowledge and leading edge technologies and/or a wide variety of multidisciplinary research expertise and research infrastructure — Influence university research directions and new programs for industry good — Access to specialized consultancy/Identify relevant problems/Solve specific technical problems — Product testing with independent credibility in testing — Training/continued professional development — Opportunity to access a wider international network of expertise — Act as a catalyst that leads to other collaborative ventures — Joint publications — Hiring of talent graduates
Social-related	— Service to the community — Enhancement of university's reputation	— Enhance reputation by becoming more social responsible business
Drawbacks		
Deviation from Mission or Objective (Core Ethic)	— Threats to research autonomy or integrity for commercial advantage that may have a negative impact on culture of open science and affect university mission — Confidentiality agreements may block the dissemination of knowledge — Could result in the abandonment of long-term basic research in favor of results-oriented, short-term, applied research and technology transfer — Concern that the end result of collaboration could be short-term contracts in which industry would require 'quick and dirty' solutions to problems, with university departments acting as extensions to the research activities of firms	— Slow academic bureaucracies may stifle technology commercialization, depress the firm's performance and delay the fulfillment of the firm's objectives — Diversion away from the 'bottom-line' issues of industry like return on capital investment — Collaboration may be costly due to increase in administrative overheads, as industry may have to develop specific managerial and administrative competencies, which may be a time-consuming process

Table 6 (*Continued*)

	Universities	Industry
Quality Issues	— Potential diversion of energy and commitment of individual staff who are involved in interaction with industry, away from core educational activities — Could affect types of research questions addressed and reduce the quantity and quality of basic research	— Low intellectual level of some contract work — Results in theoretical and impracticable solutions since university staff are too theoretical and not very practical whereas industry's focus is much more problem centered on critical situations requiring immediate attention
Conflicts	— Conflicts between researchers and company over the release of adverse results/damage in professional relationships among the researchers — Biased reporting by researchers sponsored by companies in favor of positive experimental results relating to company products	— Disharmony and discord during R&D development — Intellectual property disputes and patenting disagreement
Risks	— Dilemma of either publishing results for short-term revenue and academic recognition or withholding until they are patented, with the risk of the technology becoming obsolete — Risks that academic—industry relationships pose to human subjects of research and to the integrity of academic investigation	— Diminished control or leakage of proprietary information — High failure rate of collaborations — Financial risk to industry — Risk of incomplete transfer or non-performance of technology — Market risk where there is uncertainty of the success of the product launched in the market

assume their company seek UIC to find out how new technology can be commercialized (Adler & Kwon, 2002). Second, collaborating across the sector boundaries carries the risk of mission creep (cf. Careya, Lawsonb, & Krausec, 2011) for universities. This can take place when the main aims and functions of the universities is influenced by the commercial objectives of the business partners. In addition, as discussed in the drawbacks section, universities are subject to potential reputation damage if any of their business partners has committed unethical or socially unacceptable behavior. Such risk is particularly relevant because ''in recent years business increasingly has been viewed as a major cause of social, environmental, and economic problems. Companies are widely perceived to be prospering at the expense of the broader community'' (Porter & Kramer, 2011, p. 64). Drawing on these two issues, the dominant perception of UIC as a rational process can be therefore justified because both partners would seek to identify in advance specific and measurable objectives of their interaction, plan necessary procedures or activities, and also clarify the potential impact on organizations and society as well. Furthermore, considering UIC as a rational process would help universities in particular to carefully select their business partners, and set the limits of their involvement in terms of resources and responsibility, which would protect the universities against the risk of losing legitimacy if its business partner's reputation deteriorates as a result of social or environmental misconduct. The need for a systematic procedure would be necessary to organize this relationship and thus prevent universities from deviating from their main goal: education and knowledge development.

However, we are not aiming to draw a normative conclusion here. In other words, we do not argue that the rational view is better than the irrational one when investigating UIC. Rather we seek to provide an explanatory account of the domination of the rational view in the extant literature as observed in our analysis outcome. Despite being rare in literature, the irrational view is still an important and complementing theoretical lens when examining the nature of UIC. As explained earlier, viewing the collaboration as a political and social interaction process is essential to understand how knowledge is created when partners from heterogeneous sectors (i.e. universities and industry) collaborate. Moreover, the irrational view is relevant when studying the formation of informal 'personalized' collaboration across organizations, including university and industry (De Carolis & Saparito, 2006), where ''some critical R&D practices actually seems to follow their own trajectories and 'rationalities' without conscious managerial guidance and supervision'' (De Carolis & Saparito, 2006, p. 190). Therefore, studying the impact of informal relation and social interaction, as well as the formal one, is essential to understand innovation process in UIC (Dess & Shaw, 2001), because this process is rooted in the nature of knowledge creation as a socially embedded process (Sirmon, Hitt, & Ireland, 2007).

Underpinning theory of UIC: toward an integrative view

As discussed above, UIC in the literature has been viewed as a rational and irrational process. This implies that researchers in this area emphasize the role of interdependency (the

rational view of UIC) and interaction (the irrational view of UIC) theories in the genesis, development and maintenance of these relationships. Interdependency theories stress the impact of the external environment on the formation of UIC, while interaction theories explore the internal development and maintenance of these relationships (Geisler, 1995).

There are several perspectives of interdependency theories mentioned in the literature, including sociological perspectives, behaviorally-oriented paradigm and paradigms that originate from the discipline of economics. However, six perspectives have been observed as widely used (Barringer & Harrison, 2000), including: Transaction Costs Economics, Resource Dependency, Strategic Choice, Stakeholder Theory, Organizational learning, and Institutional Theory. Transaction Cost Economics (TCE) assumes that transaction (or economic exchange) is the basic unit of analysis for organization's economic relationships, where these relationships are sought to reduce production cost and increase efficiency (Tadelis & Williamson, 2012). Therefore, it may provide an explanation for reasons why universities and companies might be inclined to engage in a relationship; minimize the sum of their technology development cost. However, TEC can be criticized for its limited focus on efficiency maximization and cost minimizing rationale, and the deficiency in considering other important criteria like learning within the relationship (Dekker, 2004). Similarly, the Resource Dependency (RD) theory might explain the motives for UIC as the universities and the industry would perceive themselves as resources dependent. While RD theory is much appealing, it is limited in some aspects. Mainly it fails to explain why organizations might pursue other strategies beside alliances to satisfy perceived resource deficiencies such as raising new capital to obtain a resource through a market transaction (Child, Faulkner, & Tallman, 2005), which is often selected instead of alliance formation. Moreover, not every organization in an inter-organizational field is a potential source of resources for the other party (Pennings, 1981; Powell et al., 1996), which mirrors the irrational process view of UIC. The Strategic Choice (SC) theory is a useful theoretical perspective that can explains organizations' strategic decisions in terms of competitiveness. In other worlds, decision are justified if they develop a competitive advantage for a company or allow it to gain more power in a given market (Santos & Eisenhardt, 2005). This perspective, may also be relevant, as universities and companies might engage for strategic reasons (e.g. benefits from economies of scale in joint research, or get fast access to new technologies). Nevertheless, one of the greatest weaknesses of this theory lies in the sense that there is no consensus on how to sort out all of the existing UIC strategies into meaningful groups for study (Barringer & Harrison, 2000). Moreover, strategies are not equally successful across environmental contexts (Kent, 1991). Stakeholder Theory (ST) suggests that organization's stakeholder groups — those who can affect or are affected by the achievement of an organization's objectives (Freeman, 1984) — play a pivotal role in maintaining its social legitimacy (Dacin, Oliver, & Roy, 2007). In principle, organization's legitimacy can be achieved when its activities are compatible with the norms and rules of the society it operates within (Zukin & Dimaggio, 1990). Accordingly, and by reflecting on the UIC setting, universities and companies may seek collaboration to better understand and consider the interests of all relevant stakeholders in their key operational and strategic decisions (Adler & Kwon, 2002). Despite its strength, ST can be described as being ambiguous on how stakeholder interests ought to be prioritized (Langtry, 1994), and that the theory lacks context and causal law to explain the process (Jensen, 2002). Learning Theory (LT) emphasizes the role of knowledge in creating and maintaining competitive advantages (Larsson, Bengtsson, Henriksson, & Sparks, 1998). Nonetheless, because knowledge is often tacit and difficult to price and buy from the market, an organization that wants to learn a particular skill would stand a better chance of accomplishing its objective by forming a relationship with an organization that is exemplary in that area (Barringer & Harrison, 2000). Drawing on this perspective, it can be argued that UIC takes place to capitalize on opportunities for learning, since UIC would be particularly effective in exchanging knowledge across organizations (Hoffmann & Schlosser, 2001). Although the LT appears as conceptually suitable as an explanation for UIC, a weakness of the theory is that it concentrates on competency and skill development and transfer without considering the cost involved, as well as the risk of losing proprietary information that is outside the intended scope of the collaboration (Hamel, Doz, & Prahalad, 1989). Lastly, Institutional Theory (IT) asserts that organizations are subject to institutional pressures which force them to adopt specific activities to become more consistent with the norms of their external environments (Dimaggio & Powell, 1983). Driven by these pressures, universities and industry might seek the collaboration to become legitimate and conform to prevailing social norms (i.e. a result of institutional pressure). For example, a company may seek UIC to appear as ''socially responsible'' by investing in addressing society's problems through collaboration, where universities may target UIC to become more practice-related and thus being perceived as effective and accountable. Yet, it focuses on institutionalization as an outcome rather than a process resulting in neglecting the role of power (Zucker, 1987) and group interests (Perrow, 1986). Moreover, it is not easy through the IT to explain why certain forms of interactions exist, especially when they are different from the stat quo (Barringer & Harrison, 2000).

The Interaction theories (ITs), such as the social network approach (e.g. Borgatti & Molina, 2003; Brass, Galaskiewicz, Greve, & Tsai, 2004), can also be useful to understand the development, evaluation and survival of UIC (Geisler, 1995). Specifically, the ITs perceive the universities and industry as independent entities, and that a relationship could be started by any of these entities taking the initiative. Moreover, the emergence of organizational links could be facilitated by pre-existent relationship (Turnbull, Ford, & Cunningham, 1996). Thus, the ITs can explain the dynamics of UIC, and how the relationships evolve through the growth in influence of commitment, trust, and communication (Levinthal & Fichman, 1988, Ritter & Gemünden, 2003). However, such theories are limited in the sense that they focus predominantly on the on-going social interaction between organizations' actors, and underestimate the importance of managing UIC as a rational approach that requires a pre-planned and systematic view of the collaboration process and its expected outcome, as explained earlier. This is because the ITs emphasize that inter-organizational cooperation arises in the context of specific relationships and

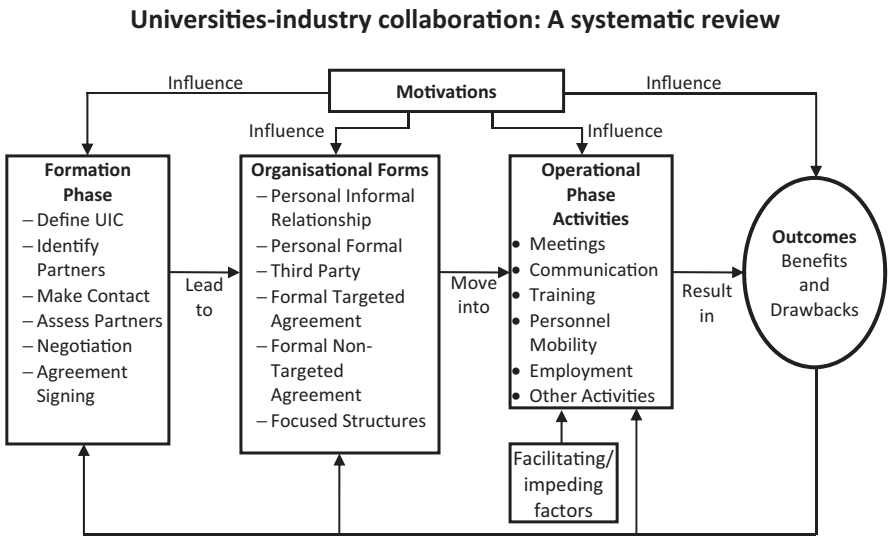

Figure 1 Conceptual process framework for UIC: an integrative view.

unfolds through on-going interaction (Heide & Miner, 1992). In other words, ITs concentrate on the process of the relationship in a dynamic manner, compared with the more static and predetermined approach of the interdependency theories (Geisler, 1995).

While the use of the interdependency and interaction theories have had important pay-off in the sense that they appeared to explain certain aspects of UIC, they were not adequate for developing a comprehensive view of this phenomenon. What this indicates is that there is an absence of a middle range theory (which is intermediate to the grand theories of interdependency and interaction theories) that could account for not only what is observed, but also those details orderly descriptions of particulars in UIC. Therefore, the outcomes of the review are rather integrated into the conceptual framework shown in Fig. 1. Depending on the complexity of the relationship, a particular form of UIC does not need to go through all of the stages or steps of the formation phase, nor does it need to experience all of the operational phase activities or all of the outcomes.

The relationship between the two organizations starts because both are influenced by various motives. The relationship formation leads to one of the organizational forms depending on the goals (or motives) of the particular relationship. Following the formation, the relationship moves into the operational phase, which is characterized by various activities and where a number of factors facilitate or inhibit the relationship. The relationship has resulted in various benefits and some drawbacks to both organizations as the outcomes. Although the motives of both organizations are important throughout the relationship, both organizations also need to be aware of the factors that facilitate and inhibit the relationship as well as the drawbacks to the relationship so that they could take proactive action to put in place well-developed policies and administrative procedures, as pointed out by Harman and Sherwell (2002), to ensure that the goals of both organizations are successfully met. Feedback loops from the "Outcomes" back into the other main stages imply that the UIC could change as a result of the outcomes.

Conclusion and pathways to future research

This paper presents the results of a systematic review on UIC for the period 1990—2014. 109 studies were selected out of over 1500 studies considered as being pertinent to the topic. These studies were then analyzed against five inductively-identified aspects by means of techniques from the field of qualitative data analysis. In the process, the main aspects (embodied by the five questions) were subdivided into various sub-themes, which were further analyzed for the two parties, universities and industry. Finally, an overarching process framework was developed to link together the various elements of the review.

The review and framework have not only provided a substantial contribution by creating a clear integrated analysis of the state of the literature, but also have indicated areas that require further investigation. First, it was observed through the review that the evaluation of the outcome of technology translation, including the benefits and the success of the alliance, is normally based on the judgment of industry or universities actors who might have determined the outcomes by comparison of a prior needs and expectations and a posteriori, actual or perceived satisfaction. However, one of the problems associated with this type of evaluation is that the actors from the industry and universities may vary in definition of the success of the interaction and its outcomes (Barnes et al., 2002). Therefore, there is a need to investigate other alternatives to more objectively measure the effectiveness of UIC, in addition to the subjective measure currently employed. For example, to what extent the number of new patents, products, publication can reflect the real value of the UIC and justify its cost and risk. In the same vein, there is a need to explore whether universities would be better off by continuing to be involved in the generation of spin-out companies or whether they

should limit their objectives to functions that do not duplicate the function of industry. Specifically, there is no sufficient evidence regarding the best dimensions to evaluate these spin-out, such as financial gains and rate of survival (Lockett & Wright, 2005). Second, the impact of academic engagement in the process of UIC is almost overlooked. For example, none of the reviewed studies have addressed the consequences of this engagement on, for example, teaching and learning experience of students affiliated to universities that engaged with the industry. This line of research can provide supporting evidence to the intangible potential value of the UIC (Perkmann et al., 2013). Third, it was evident in the review that there is a need to examine the extent of which the UIC can move from resources complementary approach to be utilized in leveraging the competitive advantages of the engaged companies. Despite several studies (e.g. Das & Teng, 2000) that can be found in the area of within-sector collaboration (i.e. business to business), it was unclear whether this would work in the case of UIC. For example, do the intellectual exchange and the fresh perspective of academic collaborators (resulting from their consistent interaction with the state-of-art knowledge) can replace or at least contribute to the R&D capabilities of a company. Valid research outcome in this direction can be critical in affecting the decision making regarding the investment in UIC by the industry. Fourth, more research is needed to examine the role of government in UIC. In the developed economies, research shows that government is a key player in facilitating the establishment and development of such collaboration (Perkmann, Neely, et al., 2011). However, we do not know if government in the emerging and developing countries, where universities are considered as pure or semi-public institutions, would follow the same pattern. In principle, the institutional relationship between the university, industry and government (or the Triple-Helix model) has three main configurations (Ranga & Etzkowitz, 2013): (1) government leads the UIC by defining objectives and putting limitations for the interaction between university and industry, (2) industry becomes the driving force for the UIC, where both university and government have limited roles (university acts as provider of academic talents, where government role is to regulate the social and economic mechanisms), (3) the three actors act as partners aiming for the transition of knowledge to society, however the university can take the lead in this configuration. Despite Ranga and Etzkowitz (2013) suggest that the latter configuration offers the most important insights for innovation, we are not sure if this suggestion is valid in all economies. Therefore, an important objective for future research is to examine whether it is better that government intervenes at all collaboration stages, or limit this intervention at specific stages (e.g. funding and policy-making). In the same vein (i.e. UIC in developing economies), other questions might include how companies can prevent knowledge-leakage when collaborating with public universities that lacks proper legal systems to protect their intellectual properties and know-how secrets. Fifth, there is a need to conduct comparative studies across different countries in relation to UIC. We do not know whether this kind of interaction can succeed in such conditions (Hong, Heikkinen, & Blomqvist, 2010). Furthermore, research in this area can investigate the extent of which inter-country UIC can contribute to the national innovation capacity of the hosting country (Jin, Wu, & Chen, 2009). Yet, it is our belief that studies in this area should not be pursued as testing existing theories/concepts about UIC, but rather there is a need to develop theoretical and empirical understanding regarding the circumstances that promote and/or restrict (e.g. cultural implication, policies inconsistencies, mismatching of national objectives) the emergence of global UICs. Finally, our study reveals that the majority of the reviewed papers are actually cross-sectional studies. Therefore, there is a need for longitudinal line of research to provide additional insights into cause and effect dynamics and also help in assessing the 'value' of the full range of outcomes of these relationships in both short term and long term scales.

Appendix A. Overview of the articles included in the review

Journal title	Total no. of articles	Articles included in the analysis
Research Policy	33	Acworth (2008), Arvanitis, Kubli, and Woerter (2008), Babaa et al. (2009), Bekkers and Bodas Freitas (2008), Boardman and Corley (2008), Bodas Freitas, Marques, and Silva (2013), Bruneel et al. (2010), D'este and Patel (2007), Eom and Lee (2010), Etzkowitz (1998), Etzkowitz and Leydesdorff (2000), Fellera et al. (2002), Fontana, Geuna, and Matt (2006), Giuliani and Arza (2009), Hayashi (2003), Hong and Su (2013), Inzelt (2004), Kaufmann and Tödtling (2001), Lee (1996), Lehrer et al. (2009), Lockett and Wright (2005), Mansfield and Lee (1996), Meyer-Krahmer and Schmoch (1998), Motohashi (2005), Mueller (2006), Pavitt (1988), Santoro and Chakrabarti (2002), Schartinger et al. (2002), Segarra-Blasco and Arauzo-Carod (2008), Siegel, Waldman, and Link (2003), Welsh, Glenna, Lacy, and Biscotti (2008), Woolgar (2007) and Wright et al. (2008)

Appendix A (*Continued*)

Journal title	Total no. of articles	Articles included in the analysis
Technovation	11	Abramo, D'Angelo, Di Costa, and Solazzi (2009), Azagra-Caro (2007), Bjerregaard (2010), Boardman (2008), Buratti and Penco (2001), Chen (1994), Craig Boardman and Ponomariov (2009), Hemmert, Bstieler, and Okamuro (2014), Geisler (1997), Klofsten and Jones-Evans (1996), Lee and Win (2004)
R&D Management	9	Bonarccorsi and Piccaluga (1994), Chiesa and Manzini (1998), Dill (1990), Enkel and Gassmann (2010), Jacob et al. (2000), Lee (2011), López-Martínez et al. (1994), Perkmann, Neely, et al. (2011), Plewa, Korff, Baaken, and Macpherson (2013)
Journal of Technology Transfer	10	Abramo, D'angelo, Di Costa, and Solazzi (2011), Caloghirou et al. (2001), Hall et al. (2001), Lee (2000), Muscio and Pozzali (2013), Okamuro and Nishimura (2013), Ponomariov (2013), Santoro and Gopalakrishnan (2001), Schartinger et al. (2001), Thune and Gulbrandsen (2014)
International Journal of Technology Management	4	Autio and Laamanen (1995), Howells and Nedeva (2003), Shenhar (1993), Wong (1999)
IEEE Transactions on Engineering Management	4	Gopalakrishnan and Santoro (2004), Santoro and Saparito (2006), Santoro and Chakrabarti (2001), Santoro and Saparito (2003)
Journal of Business Venturing	4	George (2002), Harmon et al. (1997), Mian (1997), Soh and Subramanian (2014)
International Journal of Management Reviews	3	Agrawal (2001), Dess and Shaw (2001), Santoro and Chakrabarti (1999)
Technology Analysis & Strategic Management	3	Bell (1993), Blackman and Seagal (1991), Geisler (1995)
Academy of Management Review, European Management J., J. of Management, Long Range Planning, American J. of Sociology, Organizational Dynamics, J. for Higher Education Management, Management Science, Organization Studies, J. of Higher Education Policy and Management, Industry and Higher Education, J. of Product and Brand Management, American Business Law J., Computers Industrial Engineering, J. of Engineering and Technology Management, European J. of Innovation Management, Research Technology Management, Oxford Review of Economic Policy, J. of Product innovation management, The J. of High Technology Management Research, Policy Studies Journal, Higher education, I. J. of Innovation Management, Research evaluation, Science and Public Policy, Technological Forecasting and Social Change, Papers in Regional Science	28[a]	Ring and Van De Ven (1994), Barnes et al. (2002), Barringer and Harrison (2000), Bower (1993), Culati and Gargiulo (1999), Cyert and Goodman (1997), Powers (2003), Owen-Smith, Riccaboni, Pammolli, and Powell (2002), De Carolis and Saparito (2006), Harman and Sherwell (2002), Mora-Valentin (2000), Logar et al. (2001), Newberg and Dunn (2002), Peterson (1995), Santoro and Gopalakrishnan (2000), Philbin (2008), Santoro and Betts (2002), Poyago-Theotoky et al. (2002), Duggan (1997), Siegel, Waldman, Atwater, and Link (2003), Lee (1998), Turk-Bicakci and Brint (2005), Shichijo, Baba, and Yarime (2010), Lebeau, Laframboise, Larivière, and Gingras (2008), Etzkowitz (2002), Guan and Zhao (2013), Muscio (2013), D'este, Guy, and Iammarino (2013)
Total number of articles included in the review	109	

[a] 28 articles from 28 different journals.

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