Journal of Cleaner Production 258 (2020) 120861

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Context perspective on University-Industry Collaboration processes: A systematic review of literature

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ARTICLE INFO

Article history:
Received 10 May 2019
Received in revised form
15 January 2020
Accepted 1 March 2020
Available online 4 March 2020

Handling editor: Dr Sandra Caeiro

Keywords:
University
Industry
Collaboration
Processes
Channels
Barriers
Mechanisms

ABSTRACT

Studies on University-Industry Collaboration (UIC) have mainly focused on processes at the individual and institutional levels. The result has been a proliferation of literature on aspects of UIC implementation processes often accounting for contextual differences. A survey of previous systematic reviews showed a gap in integration of knowledge on UIC implementation processes from a holistic and economic context perspective. This systematic review of the literature seeks to cover that gap by integrating the literature on UIC implementation processes from developed and developing countries contexts. In total 68 publications were reviewed and the data extracted were qualitatively analyzed using a grounded theory approach. Three major themes are distinguished: channels of interaction, UIC mechanisms, and barriers to UIC. The channels of interaction were often presented in categories. The most comprehensive were found to be bi-directional, traditional, commercial and service channels. It was found that commercial channels are ranked by both industry and academia as the least important and the least preferred by collaboration actors. The review discerned three major forms of UIC implementation processes: (1) educational collaboration, (2) academic entrepreneurship and (3) research related collaboration. Mechanisms of implementing these three forms of interaction vary, but continuous interactions are frequently proposed as the best method of knowledge transfer, contrasting with the traditional linear view of UIC processes. Regarding barriers to collaboration, five categories of barriers (misalignment barriers; motivation related barriers; capability related barriers; governance-related barriers and contextual barriers) are identified. The review indicated also that there is still a research coverage gap in developing countries compared to developed countries, and that the educational collaboration form is somehow neglected. It is therefore recommended to use an action research approach to advance research in developing countries and to provide extra attention to educational collaboration mechanisms since this form is among the preferred means of UIC.

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1. Introduction

In recent years universities have seen their mission extended to what is commonly referred to in the literature as the "*third mission*" (Dalmarco et al., 2018; Guimón, 2013; Styhre and Lind, 2010; Vega-Jurado et al., 2007). This "*third mission*" was defined by Secundo et al. (2017) as "the generation, use, application and exploitation of knowledge with external stakeholders and society in general". Therefore universities are increasingly expected to contribute to solving socio-economic problems (Ssebuwufu et al., 2012). University-Industry Collaboration as a means towards fulfilling the third mission is becoming an important point of attraction for people interested in the role of universities in a national economy (Eun et al., 2006).

University-Industry Collaboration (UIC henceforth) is multifaceted and interdisciplinary (Rajalo and Vadi, 2017; Perkmann and Walsh, 2007). Indeed a number of scholarly communities including management studies, the economics of innovation, industrial organization, the sociology of science, and science and technology policy have long been interested in the topic (Perkmann and Walsh, 2007). This multidisciplinary interest has led to various perspectives in studying and trying to understand UIC. The focus of the literature on UIC has first been on the conceptual aspects such as the form and scope of UIC, the formation of UIC, motivation for collaboration, outcomes of the collaboration, factors affecting the success of the collaboration and the underpinning theory

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https://doi.org/10.1016/j.jclepro.2020.120861
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(Perkmann and Walsh, 2007; Ankrah and AL-Tabbaa, 2015). The triple and quadruple helix models as frameworks of UIC have also been discussed (Leydesdorff et al., 2013; Etzkowitz, 2003). The recent literature on UIC tends to focus on empirical studies depicting aspects and experiences with implementing UIC in specific countries (e.g. Faisal et al., 2017; Zavale and Macamo, 2016; Kruss et al., 2015), industry (e.g. Garousi et al., 2016), universities (e.g. Ssebuwufu et al., 2012) or at scientist level (Banal-Estañol et al., 2018; Filippetti and Savona, 2017; Arza and Carattoli, 2016).

In a bid to integrate the prolific and multifaceted literature on UIC, a number of systematic literature reviews have been conducted. Among the most recent are university-industry linkages in Sub Saharan Africa (Zavale and Langa, 2018), UIC in Malaysia (Faisal et al., 2017) and in UK (Vick and Robertson, 2017), as well as UIC practices and challenges in software engineering industry (Garousi et al., 2016). Although these reviews have addressed questions related to UIC in practice and from a context-specific perspective, their limitation in content or geographical scope makes that they only provide a partial picture especially in relation to UIC implementation processes. Older reviews such as Ankrah and AL-Tabbaa (2015) and Perkmann et al. (2013) have also approached the literature on UIC from a selective content perspective. Perkmann et al. (2013) focused their study on antecedents and consequences of academic engagement, while Ankrah and AL-Tabbaa (2015) presented key aspects which underpin the theory of UIC and integrated them in a conceptual process framework. Both reviews have implicitly focused only on research related collaborations with as a consequence the proposition of partial frameworks for the conceptualization of university-industry linkages as a whole.

In fact, despite the increase in context-specific and empirical studies, to the best of our knowledge, no systematic literature review has simultaneously considered literature related to all the three forms of UIC i.e. academic entrepreneurship, educational collaboration and research related collaboration nor considered at the same time UIC processes in developed and developing countries to bring out contrasts and similarities. Through a traditional narrative literature review, Mgonja (2017) developed an overview of UIC best practices by highlighting experiences on research collaboration accumulated in developed countries and used them to advise on the improvement of UIC in developing countries. But a traditional narrative review leads to a lack of rigorous repeatable process, thereby increasing the probability of bias and the risk of overlooking relevant literature (Ankrah & AL-Tabbaa, 2015). This study intends to cover this gap by systematically reviewing the extant literature on academic entrepreneurship, educational collaboration and research related collaboration processes in developed and developing countries. According to Talwar (1993: 26), a process is a "sequence of pre-defined activities executed to achieve a pre-specified type or range of outcomes". In this review, this definition is extended to include also dynamics around the accomplishment of the pre-defined activities. The UIC implementation process can hence be understood as the set of activities, managerial dynamics, strategies, and procedures adopted by universities and/or industry firms or individual scientists engaged in collaboration to make the later successful. Three specific questions are addressed: (1) what are the key channels of interaction between universities and industry in developed and developing countries and what are the existing patterns regarding the preferences for these channels? (2) what are the mechanisms of implementing UIC at an individual or organizational level? (3) what are the barriers and challenges faced by partners in implementing UIC activities?

This paper contributes to the literature by painting a more holistic and hence clearer picture of UIC implementation processes by simultaneously reviewing the literature related to the three forms of UIC namely academic entrepreneurship, education, and research related interaction mechanisms. This holistic approach to UIC is expected to provide a more in-depth integration of the conceptual framework of UIC processes therefore leading to a better capturing of the varied facets of university-industry relationships (Bruneel et al., 2010). Furthermore, through the juxtaposition of findings from developed and developing countries, the paper brings more understanding of the similarities and contrasts between the two socio-economic contexts. This is expected to enhance more understanding of the phenomenon of UIC (Schiller and Lee, 2015; Eun et al., 2006) and inform future research directions. Unlike other systematic reviews (Ankrah and Al-Tabba, 2015; Garousi et al., 2016; Vick and Robertson, 2017) which presented the list of channels of interaction, mechanism of interaction and barriers or challenges faced, this paper allows to integrate further detailed knowledge on individual and organizational level aspects such as factors affecting the variety and use of channels, preference for given channels, trust formation and boundary spanning mechanisms, spin-off mechanisms, management of R&D projects, creating researchers' hybrid identity and managing Technology Transfer offices (TTOs). It also proposes a more inclusive categorization of the barriers to collaboration which allows integrating the individual dimension of the barriers.

Apart from the introduction, the rest of the paper is organized around the following four sections: section 2 presents the methodology used, section 3 presents findings from the systematic review, and section 4 discusses the findings. The last section presents the conclusion and recommendations for further studies.

2. Methodology

This review builds on the methodologies of other systematic literature reviews conducted in the field of UIC such as Faisal et al. (2017), Garousi et al. (2016), Ankrah and AL-Tabbaa (2015) and Perkmann et al. (2013). The procedure followed for this review is made of four phases as indicated in Fig. 1:

2.1. Phase 1: initial search for relevant literature

In this phase, a list of relevant publications was obtained using three online databases namely the Web of Science (WoS), ELSEVIER (Science Direct) and ERIC. The following key words were used to generate the list of relevant publications: *University-Industry, Academia-Industry, University Technology transfer, University outreach and Triple Helix* combined with the following terms in the title of papers (using "AND" operator): *partnership, collaboration, cooperation, alliances, links, relationships, spin offs*. For each database search, additional terms to be searched in the abstract were added (also using "AND" operator). Key terms included in this case were: *operationalization, sustainability, practices, strategies, effectiveness, determinants, antecedents, factors of success, patterns, challenges, barriers, issues, achievements, management, strategies, indicators, attitudes, and perceptions*. To include all the possible publications from all the scientific domains, three strategies were used: (1) including as many terms as possible, (2) setting the field "select database" of the search engines to "all databases", and (3) for all the three search engines, setting the search parameters to advanced search mode instead of basic search. In the specific case of WoS,

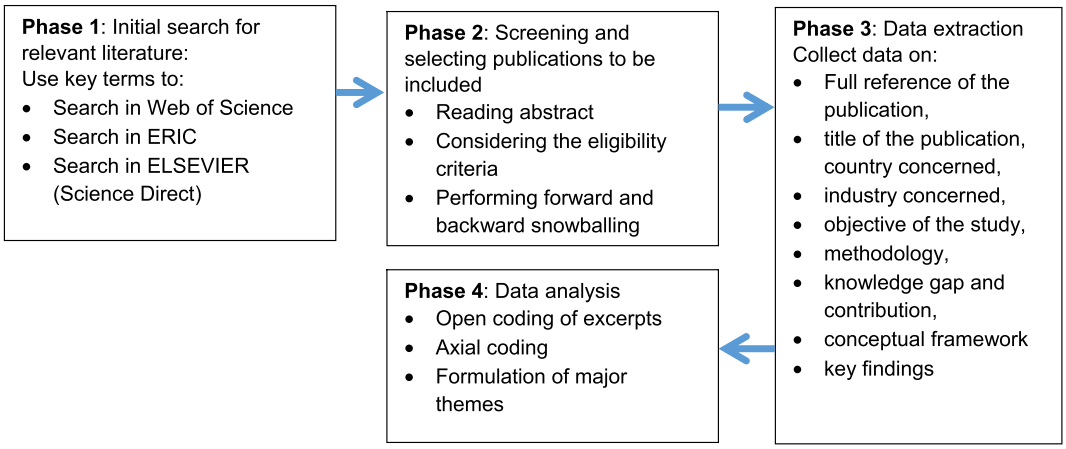

Fig. 1. Procedure followed during the systematic literature review.

researchers proceeded by iteration using key words set for title (TI) and topic (TS) search and combining sets of articles found using "OR" operator to remove duplications. Fig. 2 illustrates the search procedure for the Web of Science database.

2.2. Phase 2: screening and selecting publications to be included

In phase 2, publications obtained in phase 1 were screened by reading their abstracts and in some cases the full text, to generate a pool of papers meeting the eligibility criteria (O'Connor et al., 2011). Only peer-reviewed papers and books or book chapters published between 2007 and 2018 were considered. This period was chosen following Filippetti and Savona (2017) who argued that during the last ten years the attention of both scholars and policymakers to UIC implementation has remarkably increased. This was confirmed by results from Teixeira and Mota (2012), Perkmann et al. (2013) and Mascarenhas et al. (2018) indicating a peak in publications on UIC since the second half of the 2000s.

Unlike other systematic reviews like Ankrah and AL-Tabbaa (2015) and Perkmann et al. (2013) which proposed a conceptual integration of the existing literature and bibliometric studies such as Zavale and Langa (2018); Mascarenhas et al. (2018); Teixeira and Mota (2012) which adopted a quantitative approach with a wider temporal scope, this study is focusing only on in-depth understanding of UIC implementation. Only publications reporting implementation practices of UIC using quantitative or qualitative data drawn from field practices were considered. Other aspects common in literature on UIC such as drivers of motivation, factors affecting UIC success, antecedents of UIC, impact of collaboration, outcomes of collaboration and sustainability, which are related to the environment in which UIC implementation takes place rather than the process of implementation itself were discarded. Also not included even with field data were issues papers, research reports, theses and dissertations, and other grey literature publications. As for the content coverage, publications selected for the next phase were those with a "yes" answer to question one below and a "yes" answer to at least one of other questions from questions two to five:

1) Does the publication discuss individual or organizational level aspects of UIC practices in one or many developed and/or developing countries as its main inquiry?
2) Does the publication discuss the channels through which UIC is put in practice in developed and/or developing countries?
3) Does the publication discuss mechanisms of putting UIC in practice?
4) Does the publication discuss the management aspects of UIC in a given context/industry/country/case(s)?
5) Does the publication discuss the problems, barriers, and challenges faced during the implementation of UIC?

Regarding the quality of papers included, only peer-reviewed papers having a specific section explicitly describing the methodology used were included. Publications discarded on quality grounds were those with data judged not reliable considering the number of respondents used (one paper was discarded because it interviewed only two respondents), those with unintelligible results and the quality of journal in which a paper is published (journals which are not indexed by internationally recognized databases were not considered).

During the selection process, the researchers additionally performed forward and backward snowballing on randomly selected papers in order to minimize the risk of missing relevant studies (Garousi et al., 2016). Fig. 3 indicates a flow diagram of the search procedure and the results obtained at each stage.

2.3. Phase 3: data extraction

To effectively carry out this phase, a data collection tool was created in Microsoft excel in order to allow for easy identification and revisiting of excerpts during open coding as recommended by Wolfswinkel et al. (2013). For each publication read, data related to the full reference of the publication, title of the publication, country concerned, the industry concerned, objective of the study, methodology, knowledge gap and contribution, conceptual framework and key findings were retrieved. Appendix B provides a list of all the publications, their research objectives, and methodological features.

2.4. Phase 4: data analysis

In the fourth phase, data were analyzed using grounded theory through a two abstraction level approach (Wolfswinkel et al., 2013). The categorization of countries into developed and developing

Search History 07/06/2018:

Set	Results	Save History Open Saved History	Combine Sets ○ AND ◉ OR Combine	Delete Sets Select All Delete
# 33	566	#32 OR #31 *Timespan=2007-2018* *Search language=English*	Select to combine sets. ☐	Select to delete this set. ☐
# 32	4	TI=((Universit* AND (outreach OR spin-offs)) AND (collaboration OR link* OR partnership OR relationship OR collaboration OR cooperation OR interaction)) AND TS=(Practic* OR indicators OR achievements OR indicators OR practice OR factors OR challenges OR barriers OR issues) *Timespan=2007-2018* *Search language=English*	Select to combine sets. ☐	Select to delete this set. ☐
# 31	565	#30 OR #29 OR #28 *Timespan=2007-2018* *Search language=English*	Select to combine sets. ☐	Select to delete this set. ☐
# 30	26	TI=(industry AND (university OR academia)AND (collaboration OR link* OR partnership OR relationship OR collaboration OR cooperation OR interaction)) AND TS=((practices OR achievements OR performance OR management OR barriers OR issues OR indicators OR strategies OR effectiveness) AND (developing countries OR emerging market economies)) *Timespan=2007-2018* *Search language=English*	Select to combine sets. ☐	Select to delete this set. ☐
# 29	312	TI=(industry AND (university OR academia)AND (collaboration OR link* OR partnership OR relationship OR collaboration OR cooperation OR interaction)) AND TS=(practices OR achievements OR performance OR management OR barriers OR issues OR indicators OR strategies OR effectiveness) *Timespan=2007-2018* *Search language=English*	Select to combine sets. ☐	Select to delete this set. ☐
# 28	469	#27 OR #26 *Timespan=2007-2018* *Search language=English*	Select to combine sets. ☐	Select to delete this set. ☐
# 27	1	TI=(triple helix AND performance) AND TS=((Practic* OR indicators OR achievements OR indicators OR practice OR factors OR challenges OR barriers OR issues OR individual incentives OR attitude OR perceptions OR individual behavior) AND developing countries) *Timespan=2007-2018* *Search language=English*	Select to combine sets. ☐	Select to delete this set. ☐
# 26	469	#25 OR #24 OR #23 *Timespan=2007-2018*	Select to combine sets. ☐	Select to delete this set. ☐

Fig. 2. Illustration of iterative search from the web of science database.

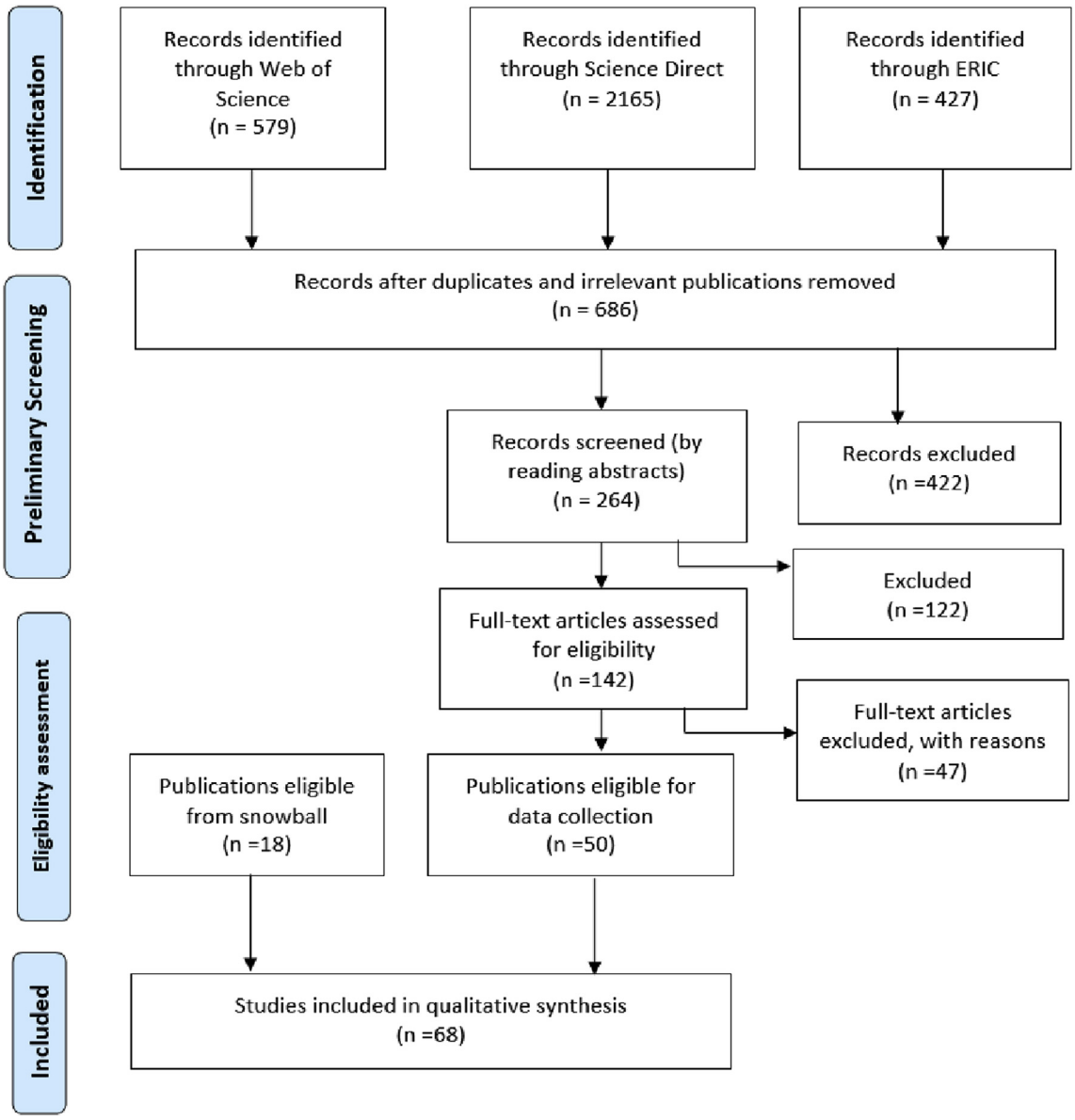

Fig. 3. Flow diagram for literature search procedures.

countries was done using the country classification by the United Nations (2019). From the coding process five key topics were identified and they are presented in the next section on findings.

3. Findings

This section presents the findings from 68 reviewed publications. Results include channels used in UIC, mechanisms, processes, strategies, and dynamics related to boundary spanning, trust formation, academic entrepreneurship, and R&D related collaboration projects. Five aspects were highlighted in several studies. First, channels of interaction mostly referred to in the literature are publication, R&D joint projects, contract research, patent and license, spinoff, students and staff training, conference and meetings, and consultancy. Second, the channels pertaining to the commercial channel category (patent, license, and spin-off) are rated the least important and least preferred channel of UIC by researchers and also by industry. Third, regarding UIC mechanisms the most highlighted aspect is the continuous character of the knowledge transfer mechanism as opposed to the traditional linear and reversed linear models. The above three aspects are common in the literature from both developed and developing countries, while most highlighted aspects about barriers to collaboration from developing countries and from developed countries differ. The literature from developing countries highlighted mostly absence of country-level policy and support, lack of adequate linkage structure (e.g. TTO) and motivation related barriers, while in developed countries university research not relevant to industry, differing requirements and expectations, lack of understanding of industry, and lack of appropriate state support are the most frequently found by researchers. Another common aspect about barriers to collaboration is the predominance of studies analyzing the barriers from

Table 1
Overview of publications used in the review by Journal of publication.

Name of the Journal	Number	Articles considered
Research Policy	8	(Gümüsay and Bohné, 2018); (De Fuentes and Dutrénit, 2012); (Bekkers and Bodas Freitas, 2008); (D'Este and Patel, 2007); (Bodas Freitas et al., 2013); (Olmos-Peñuela et al., 2014); (Mathies and Slaughter, 2013); (Jain et al., 2009)
The Journal of Technology Transfer	7	(Muscio and Pozzali, 2012); (Morandi, 2011); (Thune and Gukbrandsen, 2014); (Galán-Muros et al., 2015); (Schoen et al., 2012); (Boh et al., 2015); (Comacchio et al., 2011)
Technovation	6	(Hemmert et al., 2014); (Champenois and Etzkowitz, 2017); (Bathelt et al., 2010); (Theodorakopoulos et al., 2012); (Johnson, 2008); (Decter et al., 2007)
Books and book chapters	5	(Arza et al., 2015); (Wright et al., 2007); (Dutrénit and Arza, 2015); (Kruss et al., 2015); (Schiller and Lee, 2015)
Technological Forecast and Social Change	4	(Alexander and Martin, 2013); (Villani et al., 2017); (Chau et al., 2017); (Dalmarco et al., 2018)
Science and Public Policy	3	(Dutrénit et al., 2010); (Arza and Vazquez, 2010); (Póvoa and Rapini, 2010)
Higher Education	2	Ramos-Vielba & Fernández-Esquinas (2011) Vega-Jurado et al. (2007)
Journal of Business Research	2	(Bstieler et al., 2017); (Berbegal-Mirabent et al., 2015)
Procedia – Computer Science	2	(Nakwa et al., 2012); (Smirnova, 2014)
Other various Journals: Asian Journal of Technology; Innovation; Decision Support Systems; Environment Science & Policy; European Journal of Innovation Management; Higher Education Quarterly; Industrial Marketing Management; Industry and Innovation; Information and Software Technology; Innovation and Development; International Journal of Business and Management; International Journal of Education Development; International Journal of Technology Management & Sustainable Development; Journal of Knowledge Management; Journal of Product Innovation Management; Journal of Sport Management; Politics & Society; Procedia Computer Science; Product Management & Development; RAI Revista de Administração e Inovação; Regenerative Medicine; Research Evaluation; Revista de Gestão e Projetos; Scandinavian Journal of Management; Scientometrics; Small Enterprise Research; Software Quality Journal; Technology in Society; Technology Innovation Management Review; Technology Quality Management & Business Excellence	29	(Wang et al., 2017); (Harris and Lyon, 2013); (Bjerregaard, 2009); (Nielsen and Cappelen, 2014); (Canhoto et al., 2016); (Muscio and Vallanti, 2014); (Mikkonen et al., 2018); (Chaves et al., 2015); (Zaharia, 2017); (Zavale and Macamo, 2016); (Attia, 2015); (Gertner et al., 2011); (Bstieler et al., 2014); (Zaharia and Kaburakis, 2016); (Biscotti et al., 2012); (Fernandes et al., 2015); (May et al., 2011); (Lemos and Cario, 2017); (Tsubouchi et al., 2008); (Ryan et al., 2008); (Kayser et al., 2018); (Styhre and Lind, 2010); (Belkhodja and Landry, 2007); (O'Reilly and Cunningham, 2017); (Garousi et al., 2016); (Motoyama, 2014); (Kunttu, 2017); (Fernandes et al., 2018), (Lee, 2014)

the perspective of academic staff as compared to those studying barriers faced by the industry. On a general note, findings from the reviewed literature have rather a complementary and cumulative character i.e. the majority of publications have built on previous findings to study new aspects and therefore advance the knowledge. Thus this section continues with a detailed presentation of all the noteworthy findings. Aside from the overall synthesis of the articles included in the study, the section is organized around the following key topics identified during the data analysis: channels of interaction, trust formation, boundary spanning, UIC implementation mechanisms, and barriers to UIC.

3.1. Overview of the publications reviewed

The aim of this systematic review is to provide more understanding of UIC implementation processes in the context of developed and developing economies. Therefore studies from developed countries (USA, UK, Spain, Italy, Norway, Canada, Turkey, Netherlands, France, Ireland, Finland, Denmark, Sweden and Japan) and from developing countries (South Africa, Nigeria, Uganda, Egypt, China, Korea, Thailand, Taiwan, Malaysia, India, Brazil, Mexico, Costa Rica, Argentina, Columbia, Bolivia, Kazakhstan, Mozambique and South Korea) were analyzed. The number of studies from developed countries outweighs those from developing countries. Table 1 presents an overview of the publications reviewed per Journal.

3.2. Channels of university-industry interactions

According to Bekkers and Bodas Freitas (2008), universities and industry interact through a wide variety of channels. Different scholars have attempted to categorize those channels using certain criteria. Studies such as Dutrénit et al. (2010), Lemos and Cario (2017), Arza et al. (2015), Arza and Vazquez (2010), Dutrénit and Arza (2015), basing on the mode of interaction with industry, distinguished four categories of channels namely bi-directional, commercial, service and traditional channels while Alexander and Martin (2013) considering the dominant mode of governance used relational and transactional categories. Chaves et al. (2015) categorized information channels into channels related to the traditional role of universities and those referring to the new role as entrepreneurial universities. Other studies considered criteria such as formality (Bekkers and Bodas Freitas, 2008; Ramos-Vielba and Fernández-Esquinas, 2011) and the nature of interactions (Bekkers and Bodas Freitas, 2008; Ramos-Vielba and Fernández-Esquinas, 2011; De Fuentes and Dutrénit, 2012; Zaharia, 2017; D'Este and Patel, 2007) to come up with categories like (1) information and training (2) intellectual property rights, (3) R&D projects and consultancy, (4) human resources, (5) commercialization and IPR-related activities, (6) staff and students mobility, and (7) networking. Besides the variety of channels used in UIC, the literature also covers aspects related to preference and intensity of using channels and factors underpinning the choice and use of channels.

The majority of studies that are concerned with channels of interaction have proposed a ranking of those channels by their perceived importance or by respondents' expressed preference (D'Este and Patel, 2007; Bekkers and Bodas Freitas, 2008; Dutrénit et al., 2010; Arza and Vazquez, 2010; Chaves et al., 2015; Arza et al., 2015; Dutrénit and Arza, 2015; Zaharia, 2017). Treating those approaches as the same, two salient features are highlighted. First, traditional channels (publication, conference, graduates employment, etc.) and bi-directional channels (networking with firms, joint R&D projects, and research contracts) tend to be relatively

preferred over other channels. De Fuentes and Dutrénit (2012) analyzed the determinants of preference for a channel and identified four factors from a firm's perspective (i.e innovation capability, innovation strategy, type of Public Research Organization (PRO), origin of firms) and five factors from an academic perspective (i.e. fields of knowledge, areas of specialization, origin of funding, qualification, and the size of the research group). Second, almost all studies from both developed and developing countries found that channels related to patenting, licensing and spin-offs (commercial channels) are the least preferred by academics (Dutrénit et al., 2010; Arza et al., 2015; Arza and Vazquez, 2010; Dutrénit and Arza, 2015; Ramos-Vielba and Fernández-Esquinas, 2011) but also surprisingly by industry (Bekkers and Bodas Freitas, 2008). An exception to this low preference of commercial channels was found among respondents from China and Malaysia where these forms of interaction were ranked by respondents as important (Arza et al., 2015).

Relationships between channels and benefits of UIC (De Fuentes and Dutrénit, 2012), characteristics of individual researchers and department characteristics (D'Este and Patel, 2007) were among the factors used to explain the dynamics around the choice and use of channels. In their study on the best channel of UIC, De Fuentes and Dutrénit (2012) first show that the choice of each channel is linked to obtaining specific firm and academia benefits. They then establish a connection between firms' benefits and researchers' characteristics, from which they identify project channel, intellectual and property right (IPR) channel, and the HR channel as the best channels of interaction which maximize the benefits of involved firms. This pattern of choice and use of channels was supported by other studies such as Dutrénit and Arza (2015). Table 2 provides an overview of the findings on channels from developing and developed countries' perspectives respectively.

3.3. Collaboration mechanisms

Findings from the reviewed literature on collaboration mechanisms can be classified into three sub-themes namely trust-building, boundary spanning and UIC implementation processes. The following sub-sections present key findings from each of those sub-themes.

3.3.1. Trust building mechanisms

Trust is considered to be an essential foundation of university-industry relationship especially since according to Harris and Lyon (2013) such relationships require crossing different boundaries and hence entail an element of risk. The high importance of trust in UIC is linked to its capacity to attenuate cultural differences between university and industry, therefore removing or else reducing the potential barriers to collaboration (Hemmert et al., 2014; Harris and Lyon, 2013). The literature on trust-building mechanisms has discussed mainly trust formation mechanisms, factors influencing trust formation, trust formation bases and the changes in trust bases throughout relationship evolution. Table 3 presents an overview of these topics.

Harris and Lyon (2013) contend that the most common way of building trust is to start from existing relationships because then parties in a relationship constitute what the authors call a "small community" where each one knows the others. The authors distinguish also two other mechanisms of building trust, namely the use of intermediaries and building trust from scratch. The latter passes through mechanisms like working together, openness and putting oneself at risk from others, discussing issues democratically, gaining understanding about other disciplines, having clear and complementary roles and socializing.

Studies by Harris and Lyon (2013); Bstieler et al. (2014) and Hemmert et al. (2014) provided a list of factors influencing trust formation. In a comparative study for the USA, Japan and Korea, Hemmert et al. (2014) not only showed that tie strengths, partner reputation, and contractual safeguards are strongly linked to trust formation in all the three countries, they indicated also that those factors are mediated by the innovation champions' behavior. Furthermore, the authors demonstrated that in emerging UIC countries such as Korea, companies tend to rely on the partner's reputation for initial trust-building and on the leadership of innovation champion than in mature UIC countries like Japan and USA.

Bstieler et al. (2017) propose three trust formation bases i.e. demographic similarity (e.g. same educational background), reciprocal behaviors (e.g. reciprocal communication) as well as decision-making process similarity. Analysis of how these trust formation bases relate to the maturity of the relationship has shown that reciprocal communication is strong when the relationship maturity is intermediate while similarity in the decision-making process becomes stronger with higher relationship maturity. They hence posit that decision making similarity replaces reciprocal behavior in enhancing trust as the relationship grows more mature. Contrary to the initial hypothesis stipulating that demographic similarity constitutes the basis for trust in lower relationship maturity, tests in Bstieler et al. (2017) did not show any significant connection.

3.3.2. Boundary spanning

Collaboration between university and industry implies crossing both disciplinary, institutional and other cultural boundaries between the partners (Harris and Lyon, 2013). Studies about boundary spanning process are therefore an important aspect of UIC implementation processes. Topics discussed included boundary spanning mechanisms, boundary-spanning actors and their roles, antecedents to boundary spanning as well as intermediation process and enablers.

Technology Transfer Offices (TTOs), University Incubators (UIs) and Collaborative Research Centers (CRCs) were considered by Villani et al. (2017) and Lee (2014) as forms of boundary-spanning organizations; their key roles including mitigating the cognitive distance and increasing social and physical proximity. Another type of boundary-spanning organization proposed by Villani et al. (2017) was Hybrid Autonomous Organization (HAOs) which, to the authors, creates a boundary space in which triple helix interactions take place. Individual boundary spanners were also considered especially in the work of Champenois and Etzkowitz (2017), their role being mainly catalyzing, building trust and engaging meaningfully with participants.

The literature distinguishes several boundary-spanning mechanisms. Chau et al. (2017) studied the mechanisms from the alignment theory perspective. On top of identifying traditional 'players' in University-Industry interactions, they developed and tested a framework for organizational alignment which consists in articulating the organization's value proposition followed by elaborating alignment strategy and alignment process. Other proposed boundary spanning mechanisms include aligning the requests, needs, capabilities, and attitudes of parties (Chau et al., 2017), enlarging the social network of parties through UIs, softening bureaucracy and creating a boundary space through a HAO (Villani et al., 2017). From the situated learning perspective, Theodorakopoulos et al. (2012) analyzed the intermediation process for communities of practices (CoPs) and pointed out mechanisms related to boundary encounters like organizing workshops for members of the CoPs and boundary objects such as the early setting of agenda, goals, action plans and technology diffusion assessment framework. Table 4 describes findings related to boundary spanning studies found in the review.

Table 2
Overview of findings on channels of interaction from developed and developing countries perspectives.

Topics	Elements of findings developed countries	Elements of findings developing countries
Channels of interaction	• Scientific publications • Patents and licenses • Employed graduates • Networking with firms • Joint R&D projects • Consultancy by university staff members • Staff mobility (Staff holding positions in both a university and a business, Temporary staff exchange) • University spin-offs, spin out, joint venture • Training of students • Contract research • Sharing facilities (e.g. laboratories, equipment, housing) with universities • Training of postgraduates and internships, • Specific training of firms workers • Informal relationships	• Bi-directional channel: (Networking with firms, Joint R&D projects, Research contract) • Commercial channel: (Patents, Technology licenses, Incubators, Spin-off from Public Research Organization) • Service channel: (Staff mobility, Consultancy, and technical assistance, Informal information exchange, Training staff) • Traditional channel: (Conferences and expos, Publications, Graduates employed recently in the industry) • Types of triple helix partners and linkages ◦ With Universities: (Joint R&D, Contract R&D, Testing, Seminar, and conference) ◦ With government agencies (Controlled by laws and regulations, Facilitating regulation, Financial assistance, Testing) ◦ With innovation intermediaries: - University-based intermediary organizations (IP utilization, Consultancy, Equipment sharing, Human resource exchange) - With government-oriented intermediary organizations (Funding collaboration projects Linking with other actors Seminar and training Consultancy Equipment sharing) - With market-led intermediary organization (Trade association, Equipment sharing, Information exchange, Product/process development with an alliance, Consultancy provision, Consultancy acquisition)
Preference of channels	• Channels rating: ◦ Exploitation of patents, renting facilities or equipment and the creation of spin-offs or start-ups are lowly rated. ◦ Consulting for firms and research projects commissioned by firms followed by human resources related activities are preferred especially in social sciences and humanities. ◦ 'Classic' transfer instruments are found the most important by both academics and industry researchers. ◦ Informal links outweigh the formal linkages.	• Channels rating: ◦ Researchers value more the Bi-directional channel, particularly knowledge transfer through joint research. ◦ Firms value more the Traditional channel. ◦ The commercial channel is relatively unimportant for both industry and academia and for all forms of interaction it represents except for Chinese and Malaysian firms. ◦ Informal interactions through conferences or other types of informal information exchange are relatively important. ◦ Best channels (i.e. those with long term benefits) are project channels, IPR channels, and HR channels • Determinants of preference for a channel: ◦ Innovation capability ◦ Innovation strategy ◦ Type of Public Research Organization (PRO) ◦ Origin of firms (national or international) ◦ The size of the research group ◦ Origin of funding ◦ Individual and organizational characteristics ◦ Characteristics of knowledge especially their qualification and fields ◦ Type of technology transferred (new product, new process, etc.) ◦ The potential application of research findings
Factors affecting the variety and use of channels	• Factors affecting the use of channels: ◦ Research group size and Multidisciplinary groups ◦ The field of knowledge. ◦ Academic status and research impact of research group leaders ◦ The characteristics of the individual researcher. ◦ Previous experience of collaborative research. ◦ The amount of departmental research income. ◦ Basic characteristics of the knowledge, ◦ Scientific disciplines ◦ Organizational.	• Relationships between channels and type of technology to be transferred: ◦ Transfer of new processes is highly correlated with the use of training channel ◦ The transfer of new products is highly correlated with the use of patents as channels. ◦ New techniques are negatively correlated to patents and positively correlated to consulting, while on contrary new equipment and prototypes are negatively correlated to consulting and positively correlated to patents. ◦ The transfer of new material shows a higher correlation with publications and reports.
Impact of channels on benefits	Not applicable	• Impact on firms benefits: ◦ Project Channel (Bi-directional channel), IPR Channel (commercial channel) and HR Channel (traditional channel) are important for strengthening capabilities based on R&D ◦ HR Channel and the duration of linkages important for Strengthening capabilities based on innovation activities other than R&D ◦ Info Channel (service channel) important for improving quality • Impact on academic benefits: ◦ Info Channel, Project Channel, and HR Channel play a role in obtaining Economic benefits. ◦ Only the Info Channel has a strong and positive impact on intellectual benefits. ◦ The Project Channel and the HR Channel have less of an impact on intellectual benefits

Table 3
An overview of findings on trust formation.

Topics	Elements of findings on trust formation	
Developed countries context		
- Factors influencing trust formation	• Flexible and transparent IP policies • Innovation champion behavior • Shared governance • Project length • Basic research orientation • Firm size • Sanctions and other controls	• Being informed about the collaborators • Personalities of team members • Power relations • Tie strengths • Partner reputation • Contractual safeguards
- Mechanisms of building trust	• Capitalizing on existing relationships, • Use of intermediaries and guarantors, • Building trust through the project	
- Effect of trust on UIC	• Trust is positively related to knowledge transfer • Trust is positively related to innovation performance	
Developing countries context		
- Trust formation bases	• Demographic similarity, • Reciprocal communication, • Decision process similarity	
- Effect of relationship maturity on trust bases	• The relevance of different trust bases changes over time. • The interaction of demographic similarity with relationship maturity is not significant • Reciprocal communication is more strongly related to trust in relationships of intermediate maturity • The partner perceptions of decision process similarity are strongly related to trust formation in more mature relationships. • Partners' perceptions matter for each party's trust formation.	

Table 4
Overview of findings of boundary spanning.

Topics	Elements of findings on boundary spanning
Developed countries	
- Boundary spanning actors	• TTOs, UIs, and CRCs • HAOs • Individual boundary spanner
- Mechanisms for boundary spanning	• Creation of boundary space • Aligning university-industry interactions (value proposition and alignment process, Alignment of the requests, needs, capabilities, and attitudes of parties) • Bureaucracy simplification • Enlarging social network of parties through UIs
- Role of boundary spanning actors	• Catalyzing the creation of HAO by the UIC champion • Mitigating cognitive distance • Increasing the geographical and social proximity
- Antecedents of the boundary spanning	• Investment in i1nternal human capital • Engagement with external contractors • Networking with other centers • Size of the center
Developing countries	
- Intermediation process	• Creation of a steering group • Early setting of agenda, goals, action plans and technology diffusion assessment framework (boundary objects) • Organizing workshops and visits for CoPs (boundary encounters)
- The brokering role	• To raise awareness of the program to targeted technology recipients. • Catalyst role and in building trust and engaging meaningfully with participants.
- Intermediation enablers	• The intermediary's prior performance in the provision of similar services, • Ability to recruit other potent brokers in these efforts • The presence of structures that foster the adoption of new technologies

3.3.3. UIC implementation processes

In analyzing the extant literature on collaboration implementation processes three main perspectives of UIC processes were discerned, namely educational collaboration, university entrepreneurship, and research related collaboration. Findings on this subtheme are presented keeping these three perspectives in mind.

With regard to educational collaboration, the study by Kunttu (2017) shows how educational activities contribute to the creation of joint knowledge and learning in university-industry relationships. Four mechanisms for educational collaboration (i.e. students' projects, thesis projects, tailored degree courses, and jointly organized courses) were proposed. The author argues then that using these mechanisms, university and industry partners go through three phases of relational learning process i.e. (1) share knowledge, (2) joint sense-making and (3) knowledge integration.

The literature on academic entrepreneurship mechanisms turns around topics such as mechanisms of fostering academic entrepreneurship and creation of spin-offs (Dalmarco et al., 2018; Berbegal-Mirabent et al., 2015; Boh et al., 2015), organizational requirements for entrepreneurial university (Dalmarco et al., 2018; Styhre and Lind, 2010), mechanisms to foster spin-off (Berbegal-Mirabent et al., 2015; Boh et al., 2015), spin-off management (Wright et al., 2007), spinoff dynamics (Jain et al., 2009; Wright et al., 2007) as well as spin-off and start-up creation mechanisms

Table 5
Overview of findings about academic entrepreneurship mechanisms.

Topics	Elements of findings academic entrepreneurship mechanisms	
Developing countries		
Mechanisms for fostering entrepreneurial university	• Strategies used by an entrepreneurial university ◦ Entrepreneurial perspective (students are encouraged to develop business plans through entrepreneurship courses). ◦ External links (through internship in another university, inviting startups or innovative companies to lecture, direct texting prototype in the field, participate in international fairs and expositions, etc.) ◦ Access to university resources (startup companies incubated are facilitated to access university equipment for hardware development and testing) ◦ Innovation arrangement: (helping startup companies with managerial, marketing, HR-related and legal support and providing access to a network of investors, government agents and other partners).	◦ Scientific research: (to foster new ventures of technology transfer universities define strategic research areas, guiding scientific and entrepreneurial activities – from research labs to the technology park.) • UI admission options: ◦ Accept of only entrepreneurs with a relationship with the university ◦ Acceptance of entrepreneurs in general
Developed countries		
Spin-off taxonomy	• University spin-offs: ◦ spin-offs from university research: - Development of IP with the university support - Lifestyle spinoff/Independent development of idea without university ◦ spin-offs from university-industry joint ventures: - Venture Capital backed spinoff/formal agreement developed between the university and industry - Off-site, unsolicited innovation brought forward by a researcher • Variables considered in categorizing spin-offs: ◦ From the institutional point of view: formal involvement of the mother institution and prestige of the research group	• University spin-offs: ◦ The prospector spin-off • University-related startups: ◦ Startup by a graduate or undergraduates who have developed idea from joint classroom experience ◦ Completely self-developed firms through off-site or outside campus interactions but have social ties with the university. ◦ From the business model perspective: investor vs market acceptance and Mode of value capturing ◦ From the resource-based view: Technological, financial and human resources, social resources
Spinoff creation mechanisms	• Stages of early spinoff development: (Idea generation, Commercialization decision, Prototype generation, Founding team formation, Strategy and commercialization process determination, Fundraising to sustain activities) • Factors enabling spin-off creation: ◦ support activities, ◦ human capital resources, and support infrastructures ◦ normative framework	• Pathways of technology transfer: Pathway 1: Partnership with an experienced entrepreneur, Pathway 2: Partnership with Ph.D./post-doctoral students, Pathway 3: Partnership with Ph.D./post-doctoral students, and business school students, Pathway 4: Pure student effort, typically involving a Master's/Ph.D. student and business school student • Building an ecosystem for university entrepreneurship: • Systematic vs organic model (systematically structured network versus laissez-faire approaches); • Internal focus vs external connection model.
Organizational requirements for entrepreneurial university	• Required structure: ◦ Trading zone in-between university and industry through research centers. ◦ Soft–or softening–bureaucracy (with flexibility, adaptability and new conducive mechanisms and leadership practices) • Processes of adopting hybrid role: ◦ Delegating (establishing appropriate interfaces with other actors (TTO or a graduate student)	• Scientists strategies to cope with the commercialization role: ◦ Seek out justifications that are congruent with their extant role identity. ◦ Add elements of the new role identity onto their extant one, therefore, creating a hybrid identity. • Processes of adopting hybrid role: ◦ Buffering (i.e. protecting their role identity from the influence of norms typically associated with commercialization.)
Mechanisms foster spin-offs	• Incubation models of managing the spinoff process: ◦ Reference models: - Low selective model, - Supportive model - Incubator model ◦ Suboptimal models: - Resources deficient. - Competence deficient. • Objectives pursued by a university for encouraging spin-off: ◦ Stimulating economically profit-oriented spin-offs (with no envisaged exit to generate a financial return to investor), ◦ Stimulating exit oriented spinoff (a business that would generate a realizable financial return to investors), ◦ Stimulating self-employment related spinoffs (without a focus on profitable growth or financial returns for investors).	• University programs and practices to facilitate entrepreneurship: ◦ TTOs support activities (like Project-based classes on technology commercialization, Mentoring programs, business plan competition, Entrepreneurship education for students and faculty), ◦ The existence of a normative framework ◦ The presence of specific infrastructures to facilitate knowledge flow • Motivation to engage in commercialization: ◦ Economic motives ◦ Non-economic reasons ((a) assuming the role of custodian of the nascent technology, and (b) leveraging the invention for a larger societal benefit. The desire to prevent their nascent technologies from languishing coupled with the aspiration of making a broader societal impact)
Spin-off management process	• Activities carried out: Opportunity search and awareness creation, strategic choice how to commercialize R&D, IP assessment and protection, Incubation and business plan development, funding process, Control over the spinoff process after the startup of the spinoff company. • Strategies: ◦ For low selective model: Creating as many startups as possible; ◦ For support model: commercializing the technology developed at a PRO through means other than licensing. • Financing options: Internal funding, Debt finance, governments financing schemes (UCFs), Industrial partners, business angels, and venture capital.	• Spinoffs development processes: ◦ Development phases (Research phase, pre-organization, reorientation stage, sustainable returns phase) ◦ Development mechanisms: (nonlinear and iterative, transition from one phase to another through critical junctures). ◦ Four critical junctures identified: (opportunity recognition, entrepreneurial commitment, venture credibility, venture sustainability). • Entrepreneurial team dynamics: ◦ Types of teams: Core founding team and extended founding team ◦ Mechanisms of attracting new team member: Instrumental or economic arguments

Table 5 (*continued*)

Topics	Elements of findings academic entrepreneurship mechanisms
	◦ Following these mechanisms four types of teams are distinguished: Kinship team, solo entrepreneurs, the matched team and organic teams

(Bathelt et al., 2010). Table 5 provides key elements of findings on each topic.

The literature on research related collaboration processes encompasses a variety of topics and approaches. Some authors focused on enhancing understanding of UIC project management. Topics discussed in this regard were UIC projects organizational framework (Fernandes et al., 2015, 2018), phases of UIC program & projects lifecycle (Fernandes et al., 2015, 2018; Canhoto et al., 2016; Morandi, 2011; Thune and Gulbrandsen, 2014) as well as the principles of managing R&D projects (Morandi, 2011). Other specific aspects of the UIC process such as mechanisms to build "disinterested research" (Biscotti et al., 2012), identification and selection of the right partner (Bodas Freitas et al., 2013; Wang et al., 2017), mechanisms for intermediation of triple helix collaboration (Johnson, 2008; Nakwa et al., 2012), patterns and anti-patterns for collaboration (Garousi et al., 2016) and mechanisms for supporting University to Business Collaboration (Galán-Muros et al., 2015) were also tackled. Gertner et al. (2011), Nielsen and Cappelen (2014) and Motoyama (2014) specifically focused on knowledge transfer mechanisms and argue for continuous interactions between industry and academia (opposable to the transfer of codified forms of knowledge) as the best way of knowledge transfer. The continuous character of knowledge transfer process was more or less implicitly referred to in many other studies treating UIC mechanisms topic.

Contrary to the majority of studies in developed countries which are embedded in a strong theoretical background, studies such as Kruss et al. (2015), Schiller and Lee (2015), Arza et al. (2015) approached the UIC from a broader perspective of the National System of Innovation. They provided not only descriptions of UIC features in 12 countries of Asia, Africa and Latin America but also further knowledge on the benefits of UIC and factors associated with those benefits. Studies discussing the benefits of UIC include Lemos and Cario (2017), De Fuentes and Dutrénit (2012), Chaves et al. (2015), Arza and Vazquez (2010) and Dutrénit et al. (2010). Dutrénit et al. (2010) distinguished between firm's benefits and academic benefits. Regarding firm benefits, two types were proposed namely benefits related to long term innovation strategies and benefits related to short term production activities. Long term benefits are associated with the increase in knowledge content that leads to new ideas for research projects or with an increase in absorptive capabilities by firms while short term benefits are associated with increases in quality (De Fuentes and Dutrénit, 2012). For universities, intellectual and economic benefits are proposed. Economic benefits are associated with the provision of resources and equipment specifically linked to projects in partnership with industry while intellectual benefits are associated with learning, training, and personal satisfaction (De Fuentes and Dutrénit, 2012). Studies from African, Asian and Latin American countries incorporated in this review perceived that long-term intellectual benefits were the main rewards from PRO–I interactions. However, in Asia, economic and intellectual benefits were more balanced, whereas, in Latin America, intellectual benefits were clearly seen as more important. In the case of firms, benefits related to short-term production activities are more important than benefits related to long-term innovation strategies. Only in China and Korea, both identified as emerging UIC countries, did firms perceive that the most important rewards from interactions were those that improved their (long-term) innovative capabilities (Dutrénit et al., 2010; Arza et al., 2015; Arza and Vazquez, 2010). Table 6 presents an overview of findings on research related collaboration processes.

3.4. Barriers to UIC

Different approaches have been taken to study barriers to UIC. Muscio and Vallanti (2014) and Muscio and Pozzali (2012) considered both perceived barriers and really faced barriers while Belkhodja and Landry (2007) considered perceived barriers from non-collaborating faculty. In their study Ryan et al. (2008) included in the analysis views from academia engaged in collaboration and those from industry at the same time whereas others solely considered barriers from the perspective of academic researchers (Muscio and Vallanti, 2014; Muscio and Pozzali, 2012; Belkhodja and Landry, 2007; Vega-Jurado et al., 2007) or industry (Attia, 2015; Smirnova, 2014). Table 7 shows the types of barriers for each category comparing both developed and developing countries.

Several types of barriers were identified and categorized differently by the considered studies. Vega-Jurado et al. (2007) and Gümüsay and Bohné (2018) focused on the localization of barriers vis-à-vis institutional boundaries and distinguished between internal and external barriers while Attia (2015) and Zaharia and Kaburakis (2016) analyzed barriers from the perspective of institutional operations and categorized them into orientational and transactional barriers. On their side, Belkhodja and Landry (2007) distinguished between institutional and contextual barriers and Muscio and Vallanti (2014) grouped the sixteen considered obstacles into four categories (conflicts with companies, academic networking problems, conflicts with academic goals and nature of research).

Cause-effect relationship analyzes identified factors exerting influence on barriers and their nature of influence (Belkhodja and Landry, 2007; Muscio and Vallanti, 2014) as well as possible effects of barriers on collaboration (Zaharia and Kaburakis, 2016; Muscio and Pozzali, 2012). Among factors exerting influence on barriers the authors identified (1) the characteristics of the research produced, (2) the individual context, (3) the strategic networks developed by the researcher, (4) the environmental context, and (5) the characteristics of the partner's culture. Zaharia and Kaburakis (2016) and Muscio and Pozzali (2012) argue that these factors may increase barriers' level, decrease barriers' level or affect the probability of perceiving the barriers.

4. Discussion

In the last two decades, research on UIC has focused on implementation processes at individual and organizational level thus leading to a proliferation of literature treating the subject. A systematic literature review integrating the existing literature on UIC implementation processes and from both developed and developing context seems then necessary, considering that previous reviews have focused on other scopes or methodological approaches than this one. This study is aimed at answering three

Table 6
Overview of findings of research related collaboration processes.

Topics	Elements of findings developed countries	Elements of findings developing countries
UIC projects initiation mechanisms	• Collaboration projects initiation mechanisms: (Clearly describe project goals, make a project plan by defining, allocating and scheduling project tasks). • Initiation conditions: (emergent, engineered, embedded) • Initial modes of collaboration: (coordinated efforts, parallel projects, symbolic) • Initial objectives for long term collaboration (Train researchers for their future research projects, Produce something that does not exist in the world) • Ex-ante considerations for engaging in R&D collaboration: ◦ Considerations: (possible gains from initiating R&D collaboration, approaches to partner selection, delimitation of a shared motivating problem). ◦ Contact making strategies: (An active explorative approach versus an exploitative approach relying upon existing contacts and networks). ◦ Delimitation of a shared motivating problem: (delineated a problem area that could serve as a platform for research-driven development or development-driven research)	• Phases of UIC establishment process: Establish collaboration, identify research idea, negotiate & sign MoU, writing proposal and raise funds, execute project, complete the project • Strategies of establishing contacts in pre-linkage phases: through students, alumni, Training courses to firms, External institutional stimulus, contact established by researcher before joining the university, visibility from a prominent position held by a researcher) • Mechanisms in the establishment phase: (Timid start with the relationship involving pre-defined activities). • Mechanisms in engagement phase: (Sharing facility, relationship of trust) • Later phases include: Engagement phase, Advancement phase, Latent phase
Research partner selection	• Factors influencing researchers selection: ◦ the firm size, ◦ the absorptive capacity, ◦ technology and knowledge sourcing strategy and ◦ firm characteristics related to openness to international competition and involved in international networks.	• Mechanisms used for candidates identification: Use of heterogeneous social network (HSN) and social network-based recommendation systems, use similar companies collaborators as candidates. • Researchers selection strategies: ◦ For offline module (collaborator of collaborators strategy and collaborators of similar companies) ◦ For online module (captures the contexts of companies from online social networks & evaluates candidate researchers in the given context for recommendation) • Researchers' evaluation considerations: (Context relevance, Quality of researchers and contextual trust analysis).
UIC Project organizational framework	• Phases of Program life cycle: (program preparation, program initiation, program benefits delivery, program closure) • Phases of Project life cycle: (initiation, initial planning, execution, monitoring and controlling, project closure) • Program manager and team's key tasks: (program strategic alignment, program benefits management, program's stakeholder engagement, program governance). • Possible forms of a Program Management Office (PMO): (an individual PMO, a business unit PMO, a cooperative PMO)	Not applicable
UIC projects management practices	• R&D projects coordination and control strategies ◦ Strategies for optimizing the actual R&D collaboration process: (Mutual adjustment, Informal interactions among managers, organizing managers with a controlling motive than coordination, adoption of inter-organizational teams, Temporary group meetings of partners' R&D staff). ◦ Strategies for capitalization on collaboration outcomes: (Extend the UI interaction beyond the actual R&D project work to new projects, extension of the R&D linkage activity to other university research groups). • Principles of management for R&D projects: ◦ Building momentum, ◦ building trust, ◦ develop simple mechanisms for rapid information exchange, ◦ establish clear roles in the teams and ensure understanding of each other's terminology, ◦ standardize outputs to ensure effective fit of partners efforts, ◦ coordination on mutual adjustments supersedes coordination by plans, ◦ requirement for liaison positions held by people with formal authority and a hub role within their organizations, ◦ greater decentralization of coordination and control practices, ◦ equivocality due to technological distance is mediated by group coordination.	• Best management practices ◦ Setting clear and realistic goals; ◦ Defining responsibilities clearly; ◦ Adopting formal contractual agreements; ◦ Communicating effectively ◦ Keeping personal contact ◦ Holding an opening meeting, ◦ Recording project data, ◦ Defining clear administrative procedures, ◦ Using a software or platform for project management.
Individual level collaboration mechanisms	• Mechanisms for building 'disinterested research' through relational work: (Classifying and earmarking research monies, publication delay agreement, professional identity work and sharing the royalties, use of distinguishing terminology) • Role of associate partner in knowledge transfer (KT): (Convincing the company's staff of the need for change as well as directing, managing and delivering the project, communicating the results of their work to both the academic and the company partner), • Strategies used by the associate partner to enhance KT: (identify with the community but at the same time keep a certain cognitive distance, adapt the language to whom he/she is dealing with). • Knowledge transfer mechanisms: (A core element is the development of networks and human resource, Informal interactions among managers,	Not applicable • Benefits to obtain from interactions:

Table 6 (*continued*)

Topics	Elements of findings developed countries	Elements of findings developing countries
Mechanisms for knowledge transfer	continuous communication and dialogue, Regular meetings aiming at mutual adjustment, continuous interaction and continuous learning process) • Types of knowledge transferred: (Tacit knowledge transferred through continuous processes, Explicit knowledge transferred through reports and publications)	• To firms (Accessing public resources, Developing or improving products and processes, solve problems and facilitate the hiring of qualified personnel, strengthening capabilities based on R&D, strengthening capabilities based on innovation activities, improving quality) • To the university (Economic benefits, intellectual benefits) • To the researcher and research groups: (Economic benefits, intellectual benefits). • Academic results (New scientific discoveries, publications, new products and artefacts, new research projects, theses and dissertations, human resources and students training, commercial/ business Design, software, spin-off firms, industrial products' improvements, patents, new industrial processes
UIC intermediation	• Role of intermediate organizations: (mediator/arbitrator, sponsor/funds provider, filter/legitimator, technology broker, resource/management provider), • Reason of being of intermediate organizations: (To provide specific resources and to play specific roles that individual triple helix members either cannot provide due to a lack of possessing the necessary resource(s) or are unwilling to provide because of the negative economic costs associated to them). • TTOs governance mechanisms: ◦ Typology of TTOs: the classical TTO, the autonomous TTO, The discipline-integrated Technology Transfer Alliance (TTA) and the discipline-specialized TTA. ◦ TTOs' IP related activities: disclosing inventions, conducting early economic assessment, deciding on patenting, filing the patent, searching for licensees, negotiating the contract conditions ◦ Licensing strategy: deciding on taking in spin-out companies or not. ◦ Royalty splitting and royalty monitoring: Linear schedule used by classical and TTA and nonlinear schedule used mostly by autonomous.	Not applicable
University to Business Collaboration support	• UBC activities: Joint curriculum design and delivery, lifelong learning, student mobility, professional mobility, joint R&D, commercialization of joint R&D. • UBC support mechanisms: Top management support (at strategic level this is found to be indispensable for all UBC activities), offer incentives, offices (such as career offices, incubators), internal and external communication of UBC aimed at different stakeholders. • Degree of influence: ◦ Top management support is the mechanism with the highest influence for joint R&D. ◦ Incentives have the strongest association with the activities of joint curriculum design and delivery and professional mobility. ◦ Opening offices have the highest relation of all mechanisms for the R&D commercialization.	Not applicable

specific questions: (1) what are the key channels of interaction between universities and industry in developed and developing countries and what are the extant patterns regarding the preferences for these channels? (2) what are the mechanisms of implementing UIC at an individual or organizational level? (3) what are the barriers and challenges faced by partners in implementing UIC activities?

Regarding the channels of interaction and their preferences, the literature shows a variety of channels categorized differently depending on the criteria chosen. Categorization by Arza (2010) i.e. traditional channels, service channels, bi-directional channels and commercial channels is considered in this study to be the most comprehensive. The forms of interaction pertaining to the commercial channel category (mainly patenting, licensing and spin-off) were rated lower in importance by most of the studies in developed and developing countries. This is an indication that though the role of university as a key agent in technological development and innovation is recognized by many, universities are still inclined to pursue more traditional goals than those pertaining to the new entrepreneurial mission (Berbegal-Mirabent et al., 2013). The low popularity of commercial channels may be linked to their negative impact on UIC benefits as noted by Dutrénit et al. (2010) and Dutrénit and Arza (2010) and their inability to contribute to firms' competitive advantage (Zaharia, 2017).

A closer look at the research objectives of different publications on channels reveals two terminologies used by researchers. One is the channels of knowledge transfer (Zavale and Macamo, 2016; Alexander and Martin, 2013; Olmos-Peñuela et al., 2014; Bekkers and Bodas Freitas, 2008; Arza et al., 2015), the other is the channels of interaction (Ramos-Vielba and Fernández-Esquinas, 2011; D'Este and Patel, 2007; Zaharia, 2017; Arza and Vazquez, 2010; Dutrénit and Arza, 2015; Chaves et al., 2015; De Fuentes and Dutrénit, 2012; Dutrénit et al., 2010). Except for Chaves et al. (2015) who made a net distinction between types of interaction from what was referred to as channels of information for knowledge transfer, other researchers considered those terminologies to mean the same and therefore proposed a similar list of channels. But a separation such as the one operated by Chaves et al. (2015) seems more judicious especially considering the fact that in some mode of interaction such as academic entrepreneurship, knowledge generation (invention from research) and knowledge or technology transfer in form of spin-off, license or patent may happen in two distinguished moments (Jain et al., 2009; Wright et al., 2007).

Table 7
Overview of findings of barriers to collaboration.

Barriers category	Elements of findings developed countries	Elements of findings developing countries
Misalignment barriers	- University education and research not focused on industrial relevance - Differing requirements and expectations (novelty, total secrecy from industry or delays of dissemination of research outcomes, quality of evidence in research, focus on scale of solutions, length of the research period, deferring financial expectations) - Different types of knowledge available - Differing time management (feeling like forced to adjust to academic timetable) - Divergence about patents - Confidentiality issues and lack of secure facilities - Mistrust (worries for potential stealing of ideas plus fear for competition from colleagues) - Industry research is short-term oriented - Cognitive distance and cultural difference - Differing priorities	- University education and research not focused on industrial relevance. Lack of business interest in university research (low demand of knowledge generated by industry firms) - Differing requirements and expectations (Long-term orientation of university research (concerns over lower sense of urgency of university researchers compared to industry researchers, Mutual lack of understanding about expectations and working practices, Industrial liaison offices tend to oversell research or have unrealistic expectations) - Divergence about patents (Potential conflicts with university regarding royalty payments from patents or other intellectual property rights and concerns about confidentiality) - Confidentiality issues and lack of secure facilities, Fear of losing knowledge - University research is extremely orientated towards pure science, Universities and GRIs concerned only with big science
Motivation related barriers	- No perceived benefit in terms of career advancement - Collaboration is detrimental to career progression - Those who find funds from industry may become unpopular as some admin support is diverted to their projects. - Lack of academic rewards for dissemination work - Collaborations conflict with teaching/research duties - skepticism (entrepreneurship is not deemed respectable, it is frown upon)	- Lack of trust in the local education system - Lack of incentives for students and teachers with regards to the establishment of relationships with firms. - Low lecturers' working and salary conditions - Lack of interest of firms (Industry does not want to cooperate) - No necessity (the firm's R&D is enough to innovate) - Lack of incentive schemes - No extra funding for cooperation - Uninteresting outcomes - No influence on academic reputation - Freedom of research rules it out
Capability related barriers	- Lack of understanding of the industry - Lack of funds for proof of concept, need for funds for further development - Time pressure: Teaching, research and administrative commitments allow little time for collaborative research work - Difficult to get in contact with individuals from industry - Lack of some necessary skills - Nonaccess (no access to skills or knowledge and no access to process knowledge) - Distance (there is no interaction between nascent and experienced entrepreneurs)	- Lack of understanding of the industry - Low quality of research - Insufficient institutional support, Missing support for finding partners - Lack of adequate linkage structure (Lack of TTO, lack of a system of students exposure to the industry, Lack of collaborative infrastructure between firms and universities) - Time pressure (Other duties, no time) - Lack of training for managing partnerships - Contractual agreements are difficult - low public and private funding - Difficulties in relation to infrastructure such as ICT
Governance related barriers	- Knowing who is responsible in university, - Communication problems (Differing information among HE staff) - Delays in decision making, - lack of support from HE management - No established procedures for collaboration - Movement of contracts (turnover in companies/attrition), High personnel turnover/poor industrial strategy - Lack of adequate linkage - Rules set by the university or government-funding schemes - High personnel turnover/poor industrial strategy - Non integration: entrepreneurship is not systematic and is not part of academic remit	- Amount and complexity of procedures in research activities (example purchasing of resources and equipment) - Bureaucratic restrictions - Difficulties in dialogue
Context related	- Not many firms around in the region - Lack of access to venture capital - Lack of partnerships and networks that link researchers and users - Lack of appropriate state supports, Lack of government funding schemes - Difficulty of identifying the appropriate experts, difficult to find innovative companies, dis-misconnection (inability to find the right contacts and protection from bad ones) - Easy availability of competitive services outside the country. - IP is not important in the concerned research field	- Rules set by the university or government-funding schemes - University atmosphere not favorable for collaboration, lack of culture, lack of understanding about UIC - Students are there for a short time while projects are for long term - Geographic distance - Companies profile do not allow to see universities as supportive - Absence of country-level policy and lack of support institution from the government, - absence of specific legislation enforcing companies, particularly multi-national corporations, to fund HEIs - Absence of suitable firms to cooperate with (inability to find the right contacts and protection from bad ones) - A small number of researchers and scientists involved in the work at enterprises

Three perspectives to UIC processes were identified i.e. the educational collaboration, academic entrepreneurship, and the research related collaboration. These three perspectives corroborate findings by Perkmann and Walsh (2007); D'Este and Patel (2007); Perkmann et al. (2013) about the modes of collaboration.

Educational collaboration is to some extent neglected in research, despite it being characterized by Santoro and Chakrabarti (1999) and Kunttu (2017) as very important in improving the competences of firms. Only one study (Kunttu, 2017) which explicitly approached UIC from the educational collaboration perspective was found in the literature. In studies on channels of UIC, employment of graduates, training of staff and internship of students (which are in essence pertaining to educational collaboration) are presented as forms of interaction together with research and spin-off related types but when it comes to the collaboration processes research-related and academic entrepreneurship draw almost all the attention of researchers. A plausible explanation for this "low interest" in educational related collaboration is most probably to be looked in the tendency of researchers to consider UIC as a reaction to the reduction of public funding for research (Ahmad and Farley, 2014; Ssebuwufu et al., 2012; Wright et al., 2007), therefore considering commercialization of research which is an alternative solution to the problem of limited funds as a desirable form of UI interaction to be fostered. Three main arguments can be advanced to support the need for extra attention to educational mode of collaboration especially in developing countries: (1) the primary mission of universities is education and research (Kunttu (2017) hence collaboration through educational activities has the potential of generating benefits not only for universities and firms as institutions but also for the students who are the first beneficiaries of university services; (2) in developing countries there exist a mismatch between what students learn at school and the skills needed by industry (Ssebuwufu et al., 2012). Ramifications of this mismatch extend even to the capacity of industry firms to engage in UIC since absorptive capacity is found to be an enabler of collaboration and that absorptive capacity depends on the competences of employees recruited from university graduates. To break the vicious circle, emphasis on educational collaboration can be a solution; (3) commercial channels are seemingly not preferred by collaborators as a means of transferring knowledge, therefore extra attention to educational collaboration seems judicious since it is in line with the preferred traditional channels.

With regard to research-related UIC, findings encompass a variety of topics including collaboration intermediation, UIC projects management process and principles, UIC projects initiation and organizational framework, university to business collaboration support and knowledge transfer mechanisms. A salient feature in the literature reviewed is that knowledge transfer is often viewed as a continuous process which assumes continuous interactions, learning and mutual adjustments (Mikkonen et al., 2018; Motoyama, 2014; Gertner et al., 2011). This consideration of knowledge transfer as a continuous process transcends the traditional linear and reversed linear models of innovation which considers knowledge and technologies to be developed at university and then transferred to industry, pushed by university research (linear) or pulled by the firm needs (reversed linear). Linear and reversed linear models are judged mechanistic because they consider static needs and follow a sequential approach (Mikkonen et al., 2018) whereas the continuous model adapts well to the current fast-changing and volatile technology environment with demands (including industry's knowledge and skills demands) tending to be individualized.

Different barriers to UIC have been identified in the literature and some cause-effect relationships such as factors exerting influence on barriers studied. Besides different ways of categorizing those barriers were observed. However, the proposed categories have in common the consideration of the institutional side of barriers which to the researchers' point of view minimizes the individual level of analysis. To integrate these categorizations and to bring out the individual side of the barriers leads to a new categorization of all the barriers. New categories include then (1) misalignment barriers; (2) motivation related barriers; (3) capability related barriers; (4) governance-related barriers and (5) contextual barriers. Using this new categorization, barriers from developed and developing countries are juxtaposed and the salient feature is that the types of barriers between developed and developing countries are similar at least in breadth because in-depth some barriers (such as lack of trust in local education system, lack of incentives for students and teachers to engage in UIC, low lecturers' working and salary conditions, lack of interest of firms, no necessity) seem proper to developing countries and are inherent to their respective socio-economic contexts.

In general, the literature shows a number of dimensions at which UIC processes are approached and analyzed. First institutional and individual dimensions are considered. While mechanisms related to boundary spanning, partner selection, intermediation, etc. may be viewed as predominantly happening at the institutional level, other processes such as trust formation and micro-level processes like constructing "disinterested research" are fundamentally individual processes. The individual and organizational dimensions of UIC processes were also considered in the study by Rajalo and Vadi (2017), who, using semiotics and organizational theories propose a new interdisciplinary approach for analyzing UIC at the individual level. In this approach, the authors argue that the heterogeneity of individuals involved in UIC affects its results. They also contend that "organizations create the context for the collaboration, while motivation and maturity for that depends rather on the specific characteristics of acting individuals and teams than on general organizational processes" (Rajalo and Vadi, 2017: 43).

Other identifiable dimensions include direct and indirect dimensions as well as formal and informal dimensions. The direct knowledge transfer processes are those related to academic spin-off mechanisms while educational and research-related mechanisms are mostly indirect (Berbegal-Mirabent et al., 2013). Formal and informal processes are referred to in several studies analyzing UIC. First regarding channels of interaction, formal channels such as patenting, spinoff, contract research, R&D joint research projects, etc. are distinguished from informal channels like participation in meetings, workshops, or conferences and other personal contacts either through past experience or alumni. Second, in relation to UIC mechanisms, two types of knowledge are often mentioned, namely tacit knowledge also called embodied knowledge and codified explicit knowledge called disembodied knowledge. While the latter is transferred through formal modes such as publications, written reports, patents and licenses, the former is more informal and is transferred through continuous interactions between university and industry and social networks. This distinction of tacit informal knowledge transfer mechanisms and formal disembodied mechanisms was also brought forward by Ankrah and Al-Rabbaa (2015: 397) who argued that "UIC can be viewed as either a rational (focuses on planned resource and knowledge transfer) or irrational (located within the informal social interaction between organizations) process".

The different dimensions of UIC processes can be used here as a basis for contrasting findings from developed and developing

countries. First of all two major facts regarding UIC in developed and developing countries need to be raised: (1) a distinction between UIC processes in emerging economies like China, Korea, South Africa and Brazil, and in low-income economies is observed. While the intensity of UIC processes in emerging economies is higher than in low-income countries, university-industry relations in low-income countries are characterized by weak demand for university knowledge by the industry, indirect interactions and often taking place informally (Kruss et al., 2015; Zavale and Macamo, 2016) (2) there is still an important research coverage gap between developed and developing countries in relation to UIC processes. Quantitative-wise the amount of research conducted in developed countries on UIC is far more than those conducted in developing countries (of the 68 publications used 49 are from developed countries). Content-wise, it was observed in this review that studies focusing on the individual processes dimension were either from developed or emerging economies whereas the majority of the literature from low-income countries studies are rather at institutional level dimension and diagnostic oriented (i.e. assessing the "what" rather than the "how" question). Also worth noting is a quasi-absence of studies on academic entrepreneurship and educational collaboration in the literature from developing countries. Ssebuwufu et al. (2012) consider that these problems are linked to lack of financial resources, lack of intellectual property (IP) expertise, business and project management skills, and other types of capacity required, while Zavale and Macamo (2016) and Kruss et al. (2015) view it as a result of low absorptive capacity of industry, low investment in R&D activities, weak institutions and low capability of universities in developing countries.

The content-wise differentiation in the study focus between developed and developing countries can be attributed to the differentiation in the conceptual framework. Schiller and Lee (2015) contend that research on UIC in developing countries requires additional conceptual modifications. Considering the fact that learning to assimilate and improve acquired technology together with building technological and academic capabilities are the most important roles of innovation system in most developing countries, adopting an ex-ante approach with a focus on system building instead of an ex-post approach based on system analysis (Schiller and Lee, 2015) is most probably what leads to more institutional dimension of studies in those countries. Taking into consideration the necessity for this ex-ante conceptual approach, future directions of research on UIC especially in low-income countries where the industry is still nascent and collaborations are still weak, should be oriented towards the adoption of a more action research approach. This approach would allow conducting not only diagnostic studies but also further them with other steps like action planning, implementation, evaluation and specifying learning (Susman and Evered, 1978). Besides, on a more general note, further research on UIC processes should pay extra attention to educational collaboration perspective especially on strategies to align universities' educational services to the fulfillment of the "third mission". Aligning the university's offer to partner's demand may be a better strategy of overcoming the many barriers faced in UIC, especially those related to misalignment between academic offer and industry demand. In their studies, Chau et al. (2017) propose an alignment framework that is expected to support a strategic and inclusive process for business engagement in universities, but to the authors, the framework needs to be further refined and empirically validated.

5. Conclusions

The literature on UIC is broad and encompasses a variety of disciplines. The aim of this systematic review of the literature was to provide more understanding of UIC processes in the context of developed and developing economies. In total 68 studies conducted in developed and developing countries were reviewed and data extracted were qualitatively analyzed. Based on findings, this study concludes that: (1) there exist a varied number of channels through which universities and industry interact; (2) despite the need for commercial channels subsequent to a number of pressures to university and firms, these channels are lowly preferred by both industry and researchers and hence not effectively put in practice; (3) in contrast to the linear and the reversed linear models of analysis to UIC, innovation and knowledge transfer are better implemented through continuous interaction processes; (3) educational collaboration is to some extent neglected yet forms of interaction in traditional, service and bidirectional channels which are associated with it have been ranked high in preference; (4) barriers to UIC are varied and can be grouped into five categories i.e. misalignment barriers, motivation related barriers, capability related barriers, governance-related barriers and contextual barriers, and (5) there is still an important research coverage gap between developed and developing countries in relation to UIC processes. The particularity of findings presented herein lies in their holistic and context perspectives. The literature on three major forms of UIC (educational collaboration, R&D related collaboration and academic entrepreneurship) was simultaneously reviewed, and this allows to better grasp the phenomenon of UIC in its different facets. In this regard, the paper consolidates different knowledge from the literature on detailed aspects of UIC implementation processes such as channels of interaction and determinants of their choice, trust formation, boundary spanning, spinoff mechanisms, R&D collaboration mechanisms and barriers faced. Furthermore by juxtaposing findings of studies from developed and developing countries, the paper allows to visualize contrasts between those two contexts therefore providing an orientation for future directions of research related particularly to UIC implementation in developing countries which was reported by many scholars as still under researched.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Silas U. Nsanzumuhire: Conceptualization, Methodology, Investigation, Formal analysis, Writing - original draft, Writing - review & editing. **Wim Groot:** Conceptualization, Supervision.

Acknowledgment

Researchers hereby acknowledge the financial support from NUFFIC through MDF Training and Consultancy and Mott MacDonald. They are also thankful to the reviewers of this paper for their remarkable contribution in its quality improvement. Finally the authors are grateful for the technical and moral support provided by Dr. Gilbert A. NDAYISABA, especially during the literature search and screening phase.

Appendix A. Overview of the themes and sub-themes from the reviewed studies

Themes	Context	Sub-themes	Publications concerned
Barriers to collaboration	Developed countries	- Misalignment barriers; - Motivation related barriers; - Capability related barriers; - Governance related barriers - Contextual barriers	(Zaharia and Kaburakis, 2016); (Decter et al., 2007); (Gümüsay and Bohné, 2018); (Tsubouchi et al., 2008); (Muscio and Pozzali, 2012); (Muscio and Vallanti, 2014); (Ryan et al., 2008); (Garousi et al., 2016); (Belkhodja and Landry, 2007); (O'Reilly and Cunningham, 2017)
	Developing countries	- Study perspective, - types of barriers	(Smirnova, 2014); (Attia, 2015); (Vega-Jurado et al., 2007).
Channels of interaction	Developed countries	- The predominant mode of governance - Use of channels - Factors explaining the use	(Alexander and Martin, 2013); (Bekkers and Bodas Freitas, 2008); (Olmos-Peñuela et al., 2014); (Ramos-Vielba and Fernández-Esquinas, 2011); (D'Este and Patel, 2007); (Zaharia, 2017); (Muscio and Pozzali, 2012)
	Developing countries	- Use of channels - Factors explaining the use - Relationship between channels and technology types	(Arza and Vazquez, 2010); (Dutrénit and Arza, 2015); (Arza et al., 2015); (Chaves et al., 2015); (De Fuentes and Dutrénit, 2012); (Dutrénit et al., 2010); (Zavale and Macamo, 2016); (Póvoa and Rapini, 2010)
Collaboration mechanisms	Developed countries	- Trust formation	• Trust factors (Bstieler et al., 2014), (Hemmert et al., 2014). • Trust mechanisms (Harris and Lyon, 2013)
		- Boundary spanning	(Champenois and Etzkowitz, 2017), (Chau et al., 2017), (Lee, 2014), (Villani et al., 2017), (Comacchio et al., 2011)
		- Collaboration projects management	(Fernandes et al., 2015), Fernandes et al., 2018), (Canhoto et al., 2016); (Bathelt et al., 2010), Biscotti et al., 2012); (Berbegal-Mirabent et al., 2015); (Mikkonen et al., 2018); (Garousi et al., 2016)
		- Collaboration study perspectives (educational collaboration, academic entrepreneurship, research collaboration, Holistic perspective)	• Educational collaboration (Kunttu, 2017) • Academic entrepreneurship (Bathelt et al., 2010), (Berbegal-Mirabent et al., 2015), (Styhre and Lind, 2010), (Wright et al., 2007), (Boh et al., 2015), (Jain et al., 2009) • Research collaboration (Motoyama, 2014), (Fernandes et al., 2015), Fernandes et al. (2018), (Biscotti et al., 2012), (Mikkonen et al., 2018), (Canhoto et al., 2016), (Morandi, 2011), (Thune and Gulbrandsen, 2014), (Johnson, 2008), (Galán-Muros et al., 2015), (Lemos and Cario, 2017), (Mathies and Slaughter, 2013), (Bjerregaard, 2009). • Knowledge transfer mechanisms (Gertner et al., 2011), (Nielsen and Cappelen, 2014), (Schoen et al., 2012). • Holistic perspective (Bodas Freitas et al., 2013)
	Developing countries	- Trust formation - Boundary spanning	Trust factors (Bstieler et al., 2017) • Intermediation process (Theodorakopoulos et al., 2012) • The brokering role (Theodorakopoulos et al., 2012) • Intermediation enablers (Theodorakopoulos et al., 2012) • Boundary objects and boundary events (Theodorakopoulos et al., 2012)
		- Collaboration management - Collaboration study perspectives	(May et al., 2011); (Wang et al., 2017), • Research collaboration (Wang et al., 2017), (May et al., 2011), (Kayser et al., 2018), • Academic entrepreneurship (Dalmarco et al., 2018) • Holistic perspective (Nakwa et al., 2012), (Kruss et al., 2015), (Schiller and Lee, 2015).

Appendix B. List of the reviewed publications, their research objectives and methodological features

#	Publication	Country concerned	Research Objective	Elements of methodology
1	Smirnova (2014)	Kazakhstan	This paper studies the attitudes of telecommunications companies towards knowledge collaboration with universities and outlines the factors hindering university-industry collaboration.	• Sample: 52 telecommunication companies • Data collection: Self-administered questionnaires • Type of data: Quantitative and qualitative
2	Tsubouchi et al. (2008)	Japan	To identify which factors are important barriers to effective collaboration between Japanese academia and industry in the field of regenerative medicine.	• Sample: 9 Japanese companies plus two academics • Data collection: Interview • Data type: Qualitative
3	Zaharia & Kaburakis (2016)	USA	To explore trends in collaboration barriers among various research involvement levels of U.S. sport firms with sport management academia.	• Sample: 303 useable questionnaires out of 18,206 questionnaires sent • Data collection: web-based questionnaires. • Data type: Quantitative
4	Gümüsay & Bohné (2018)	UK	This study provides answers to the following question: 'What are individual and organizational inhibitors to the development of entrepreneurial competencies in a university and how do these inhibitors function?'	• Sample: 55 people involved with entrepreneurship • Data collection: Interview, documentary and observation • Type of data: Qualitative
5	Attia (2015)	Egypt	It aims to identify the barriers and the drivers to university −industry collaboration.	• Sample: 162 out of 338 questionnaires sent to companies' CEO or top managers • Data collection: Self administered questionnaire • Type of data: Quantitative
6	Garousi et al. (2016)	Canada and Turkey	To characterize a set of collaborative industry− academia R&D projects in the area of software testing conducted by the authors with respect to a set of challenges, patterns and anti-patterns identified by a recent Systematic Literature Review study.	• Sample: Ten IAC projects all in the area of software testing • Data collection: The authors and industrialists ranked the challenges, patterns and anti-patterns, then they calculated mean values and standard deviations of ordinal Likert scale data • Type of data: Quantitative and qualitative
7	Muscio & Vallanti (2014)	Italy	This paper investigates U−I collaboration agreements and academics' perceptions of the drivers of and obstacles to U−I collaboration	• Sample: 197 completed questionnaires out of 1047 sent to directors of Italian academic Departments • Data collection: Questionnaire survey • Type of data: Quantitative
8	Muscio & Pozzali (2012)	Italy	To assess whether and to what extent the phenomena linked to the social and cultural divide that has been traditional between universities and firms, is presenting a barrier to the development of university-industry interaction and collaboration.	• Sample: 197 completed questionnaires out of 1047 sent to directors of Italian academic Departments • Data collection: Questionnaire survey • Type of data: Quantitative
9	Belkhodja & Landry (2007)	Canada	To determine the researcher's collaboration with industry and the government, what determines the barriers that affect collaboration, and to determine the differences and the similarities that exist between the two sets of factors	• Sample: 1554 researchers funded by the Natural Sciences and Engineering Research Council of Canada (NSERC). • Data collection techniques: survey was administrated by telephone • Type of data: Quantitative
10	Ryan et al. (2008)	Ireland	To assess the current status of HE−industry interaction in Ireland.	A multi approach methodology consisting in desk research, semi-structured interviews, a series of focus groups discussions and a 'brainstorming' workshop Type of data: Qualitative
11	Decter et al. (2007)	UK & USA	The aim of this study is to highlight the barriers to this process and suggest possible solutions through gaining a better understanding of technology transfer professionals' perceptions of them.	• The UK sample was 32 and the USA sample was 57 university technology transfer officers and senior executives from technology acquiring companies • Data collection: Survey built from previous Semi-structured interviews • Type of data: Quantitative
12	Vega-Jurado et al. (2007)	Bolivia	This article examines the implications of how academics respond to the debate on the production of knowledge and its transfer to the productive sector, for the transformation of Latin American universities.	• Sample: 349 lecturers from four of the 10 public universities in Bolivia • Data collection: Survey sent via email • Data type: Quantitative
13	O'Reilly & Cunningham (2017)	Ireland	To bring forward the Principal Investigator (PI) observations on the enablers and barriers to successful technology transfer of university research to SMEs.	• Sample: Ten PIs from projects • Data collection: Interview • Data type: Qualitative
14	Bstieler et al. (2014)	USA	The aim of this paper is to enhance our understanding of productive UI collaborations, by examining how university IP policies and shared governance facilitate trust formation and what role UI champions play in this process.	• Sample: 105 firms having engaged in collaborative projects • Data collection: a survey of chief scientists or CEOs • Type of data: Quantitative
15	Harris & Lyon (2013)	France	To examine the different professional cultures among research collaborators, the incentives they have to cooperate, and the processes of building trust.	• Sample: ten case studies of research collaborations (in total of 42 interviews) • Data collection: Detailed semi structured interview • Data type: Qualitative
16	Hemmert et al. (2014)	US, Japan and South Korea	To investigate how relational mechanisms facilitate trust formation in university−industry research collaborations (UICs) in three countries and to contribute to the understanding of international similarities and differences in UICs by considering institutional factors, specifically, the strength and maturity of UICs in each country.	• Sample: 618 collaborations with 237 firms in the biotechnology industry, 193 in the microelectronics industry, and 188 in the software industry. • Data collection: A structured questionnaire • Data type: Quantitative
17	Bstieler et al. (2017)	South Korea	This study examines how trust in inter-organizational relationships develops over time. Specifically, the authors study the moderating effect of relationship maturity with various	• Sample: 98 UI dyads • Data collection: Survey questionnaire • Data type: Quantitative

(*continued*)

#	Publication	Country concerned	Research Objective	Elements of methodology
			trust bases in the context of university-industry (UI) research collaborations.	
18	Chau et al. (2017)	UK	To identify ways of how to raise the efficiency and productivity of KTOs, how to attract and train staff with suitable qualifications/capabilities and how to change adverse attitudes towards knowledge exchange by some academics.	• Sample: 18 experienced actors of KE • Data collection: Interviews • Data type: Qualitative
19	Lee (2014)	Japan	This paper aims to analyse the different functions and structures of boundary-spanning organizations that successfully coordinate UI collaboration with diverse industrial resource providers.	• Sample: 21 directors and officers of industrial liaison offices, TLOs and UICRC • Data collection: Interviews and secondary sources (government archival and scientific journal). • Data type: Qualitative
20	Champenois & Etzkowitz (2017)	USA and France	This study seeks to analyse the creation and activities of organizations supporting innovation and operating in boundary spaces: existing between institutional spheres without belonging to any of them.	• Sample: 34 representatives Atlanpole and StartX and entrepreneurs • Data collection: Interviews and secondary data from archives and press reviews • Data type: Qualitative
21	Villani et al. (2017)	Italy	The aim is to find out how intermediary organizations facilitate proximity dimensions between academia and industry to improve technology transfer.	• Sample: 9 intermediary organizations facilitating technology transfer. • Data collection: Interviews • Data type: Qualitative
22	(Comacchio et al., 2011)	Italy	This paper addresses the following research questions: do TTCs that operate in contact with firms perform an activity of boundary spanning with universities? What are the antecedents of the boundary spanning of TTCs?	• Sample: 65 TTCs (39 in the Veneto, 18 in Friuli and 8 in Trentino) • Data collection: questionnaires, analysis of the web sites and documents • Data type: Quantitative and qualitative
23	Zavale & Macamo (2016)	Mozambique	The paper examines the kind of knowledge universities transfer to industry, the knowledge channels used, the incentives and barriers faced, including influencing contextual conditions.	• Sample: 119 six universities staff • Data collection: Survey of universities followed by key informant interviews • Type of data: Quantitative and qualitative
24	Ramos-Vielba & Fernández-Esquinas (2011)	Spain (Andalusia region)	The overall objective is to show the complexity of relationships between researchers and firms in a university system, and to identify some specific factors that influence such interactions.	• Sample: 765 research teams from Andalusia • Data collection: Survey using interview • Type of data: Quantitative and qualitative
25	De Fuentes & Dutrénit (2012)	Mexico	The paper discusses the impact of drivers of collaboration on channels of interaction, and the impact of these channels on the perceived benefits by researchers and firms.	• Sample: 385 researchers ascribed to PRO and 325 R&D managers from firms • Data collection: Two surveys • Data type: Quantitative
26	Bekkers & Bodas Freitas (2008)	Netherlands	The aim of this paper is to analyse how the importance of different knowledge transfer channels can be explained by the myriad of various factors.	• Sample: 575 university researchers and 454 industrial researchers • Data collection: two related questionnaires one to university researchers and one at industry researchers • Data type: Quantitative
27	Alexander & Martin (2013)	France and England	The paper has two main objectives: 1. To identify different models of knowledge or technology transfer, by considering both the comparative levels of activity and the support provided by the respective transfer offices accordingly; 2. To highlight, within each model, the most important outcomes achieved by each transfer office;	• Sample: 15 projects from UK and 15 projects from France • Data collection: Face to face interviews with respondents experienced in knowledge transfer activities • Data type: Qualitative
28	Chaves et al. (2015)	Brazil	The aim of this paper is to analyse the contribution of universities and research institutes to the Brazilian innovation system, showing that Brazilian universities contribute in several and different ways to knowledge generation in firms.	• Sample: 1005 research groups out of the 2151 research groups • Data collection: Questionnaire. • Data type: Quantitative
29	Dutrénit et al. (2010)	Mexico	Based on micro data, this paper explores which channels are the most effective for triggering different benefits perceived by researchers and firms involved in such interactions in Mexico.	• Sample: 385 researchers ascribed to PRO and 325 R&D managers from firms • Data collection: Two surveys • Data type: Quantitative
30	Zaharia (2017)	USA	The purpose of this study was to assess, for the first time, the degree to which different channels of research interaction could be used to inform the research involvement levels of sport organizations with sport academia.	• Sample: 292 useable questionnaires out of 18,206 questionnaires sent • Data collection: web-based questionnaires. • Data type: Quantitative
31	D'Este & Patel (2007)	UK	The aim of this paper is to investigate the factors that underlie the decision to interact with industry across a range of interaction channels using data collected from individual university researchers.	• Sample: 55 people involved with entrepreneurship • Data collection: Interview, documentary and observation • Type of data: Qualitative
32	Arza et al. (2015)	Argentina, Brazil, etc.	The aim of this chapter is to compare the use of different channels to transfer knowledge, and the achievement of benefits of PRO–I interactions across developing countries in Latin America, Asia, and Africa.	The empirical evidence is drawn from original micro- data collected through country surveys of firms and researchers.
33	(Arza and Vazquez, 2010)	Argentina	The aim of his paper is to discuss the relative effectiveness of different channels.	• Sample: 354 firms which have had declared involvement in interactions with PRO and a control group of 384 with no previous interaction with PRO and 136 researchers. • Data collection: Survey using questionnaire for firms and online questionnaire • Type of data: Quantitative

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#	Publication	Country concerned	Research Objective	Elements of methodology
34	Póvoa & Rapini (2010)	Brazil	This article aims to contribute to this literature by analyzing the technology transfer process from universities and public research institutes to firms in Brazil.	• Sample: 262 researchers out of 969 questionnaires sent. • Data collection: Questionnaire by email • Type of data: Quantitative
35	Dutrénit & Arza (2015)	Argentina, Brazil, Costa Rica, and Mexico	This chapter analyses the relationship between channels of PRO—I interactions and benefits in four Latin American countries from the perspective of both researchers and firms.	This chapter is based on research results from four countries that used common datasets.
36	Kunttu (2017)	Finland	The main goal of the study was to analyse the mechanisms and practices that are related to the educational aspects of this collaboration	The author used a comparative qualitative multi case study approach. Case studies were selected purposively following the concept of information-rich cases. Data were collected by interviews with both academicians and managers in R&D involved in educational collaboration activities.
37	Wang et al. (2017)	Hong Kong China	The aim of the paper is to propose a context aware researcher recommendation system to encourage UIC on industrial R&D projects.	• Sample: Offline experiments: 130 companies randomly selected together with 100,000 researchers for recommendation. • Type of data: Quantitative
38	Bathelt et al. (2010)	Canada	The paper aims to develop a spin-off typology that emphasizes a knowledge perspective, and links the spin-off phenomenon to regional development in a dynamic perspective.	• Sample: 47 spinoffs from University of Waterloo, 14 firms linked to the University of Guelph and 227 startup firms. • Data collection: semi-structured interviews • Type of data: qualitative
39	Fernandes et al. (2015)	Portugal	This paper aims to make some contribution to theory as well as to practice by discussing a new (PPM) approach specifically devoted to support collaborative university-industry R&D funded contracts.	The research methodology is divided in four phases: problem analysis; solution design; solution evaluation; documentation and communication. In the first phase interviews were conducted with projects managers and officers.
40	Fernandes et al. (2018)	Portugal	The aim of this paper is to present what are the set of key functions and responsibilities established for the overall PgPMO, as well as by proposing how to operationalize this set of functions.	Study used two cases HMIExcel and IC-HMI. The research used observation and informal focus groups methods. The observation method was adopted in a participative approach, and the informal focus groups were run without a rigid structure, involving several free-flowing discussions.
41	Berbegal-Mirabent et al. (2015)	Spain	This study examines factors that explain the creation of university spin-offs.	• Sample: Dataset from 63 Spanish universities (46 public and 17 Private) • Data collection: Used already existing dataset • Type of data: qualitative.
42	Biscotti et al. (2012)	USA	This article examines how to ensure that nonprofit academic organizations retain their status as “disinterested” knowledge producers, committed to “scientific” interests over commercial concerns, as actors embedded within these organizations engage in exchange relationships with for-profit organizations.	• Sample: 200 scientists and administrators from nine research universities and thirty agricultural biotechnology companies, • Data collection: Interview • Type of data: Qualitative
43	Mikkonen et al. (2018)	Finland	To answer the following research questions: How can high-quality, ambitious software engineering research in a collaborative setup be conducted quickly and on a large scale? How can real-time business feedback to continuously improve candidate solutions be gained?	• Sample: Representatives from four companies involved in two national Finnish software research programs • Data collection: Semi-structured interviews • Data type: Qualitative
44	Canhoto et al. (2016)	UK	This paper determines how the various contextual layers shape the co-production of value propositions in university—industry R&D collaboration, in the digital arena.	• Sample: 36 individuals in six groups • Data collection: Group interviews filmed and notes on flipcharts and notebooks • Type of data: Qualitative
45	May et al. (2011)	Malaysia	To understand the factors that relate to current project management practices and the methodology applied.	• Sample: 19 interviewees from University and SMEs • Data collection: Interviews conducted face to face or via skype • Type of data: Qualitative
46	Bodas Freitas et al. (2013)	Italy	This paper provides a better understanding of the two forms of governance and of the characteristics of firms that are involved in one or the other mode of interaction.	• Sample: 1052 firms • Data collection: a questionnaire integrated into the quarterly regional economic foresight survey of Piedmont's Chamber of Commerce. • Type of data: Quantitative
47	Morandi (2011)	Italy	The present study sheds some light on the management system of R&D cooperative agreement by examining the coordination and control modes exploited by participants to integrate and supervise their efforts in a joint research project. The focus is on industry— university collaborative researches.	The study used a multi-case design. Data were collected using face to face semi-structured in depth interviews with both the participants of the joint research project. Two distinct questionnaire for academic and industrial partners were used.
48	(Thune and Gulbrandsen, 2014)	Norway	The aim of this paper is to investigate how research partnerships between firms and universities emerge and evolve over time, focusing on the relationship between initial conditions and development trajectories.	• Sample: Six cases of multiparty consortia involving several academic and industrial affiliates • Data collection: longitudinal comparative case study for a period of 3 years. Using documents, field observation and in-depth interviews • Type of data: Qualitative
49	Theodorakopoulos et al. (2012)	Columbia	The aim of this paper is to demonstrate how technology transfer from university to rural industry can be effected by using academic-related research and advisory centers as intermediaries.	• Sample: 3 CoPs (a coalition of PIRc, University of Cauca, 2 regional Government agencies and regional chamber of commerce; a 44 fish farmers and 35 coffee producers) • Data collection: Data were collected longitudinally through participant and non-participant observation and feedback interviews, using log books and feedback sheets, during steering group meetings (six occasions), workshops (12

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#	Publication	Country concerned	Research Objective	Elements of methodology
				occasions) and follow up visits throughout the program (totaling 397 occasions). • Type of data: Qualitative
50	Gertner et al. (2011)	UK	This article seeks to examine the detailed processes of knowledge flow and learning within KTP projects through the lens of the communities of practice (CoPs) approach to situated learning.	• Sample: A multiple case study approach involving three separate KTPs projects • Data collection: Archives, interviews, questionnaires and observations. • Type of data: Qualitative
51	Nakwa et al. (2012)	Thailand	This paper explores the roles innovation intermediaries play in stimulating triple helix networks in Thai SMEs.	• Sample: 30 and 17 firms from ceramic and furniture industries respectively • Data collection: Interviews, questionnaire administration and observations • Type of data: qualitative
52	(Kayser et al., 2018)	Brazil	The purpose of this study is to empirically identify best management practices in UI collaborative projects and to present a guide for these practices.	• Sample: 4 U–I collaboration projects (2 successful and 2 unsuccessful) • Data collection: interview • Type of data: Qualitative
53	Johnson (2008)	Canada	The paper illustrates how an intermediate organization can help triple helix partnerships towards the successful commercialization of new technologies.	• Sample: 21 actors from 6 in-depth case studies of projects • Data collection: 1 h detailed interviews • Type of data: Qualitative
54	Dalmarco et al. (2018)	Brezil	The aim of this study is to identify potential activities and policies that help encourage academic technology transfer and spin-off creation in Brazil	• Sample: Managers from four business incubators and entrepreneurs from 14 incubated companies • Data collection: semi-structured questionnaire and strategic plans of the universities and external consulting companies • Type of data: Qualitative
55	Galán-Muros et al. (2015)	33 countries of Europe	This paper identifies and evaluates the mechanisms that European HEIs are using to nurture industry collaboration at strategic and operational level and assess their relationship with seven UBC activities.	• Sample: 2157 HEI managers from different types of HEI • Data collection: Self administered survey questionnaire • Type of data: Quantitative
56	Nielsen & Cappelen (2014)	Denmark and Norway	The aim of this study has been to take a closer look at the mechanisms of knowledge transfer and knowledge sharing between stakeholders in university-industry collaboration projects.	• Sample: 35 company representatives (19), researchers (12) and students (4) • Data collection: Semi-structured interviews • Type of data: Qualitative
57	Olmos-Peñuela et al. (2014)	Spain	The aim of this research is to achieve a better understanding of the processes underlying knowledge transfer (KT) in social sciences and humanities (SSH).	• Sample: 97 CSIC SSH research groups • Data collection: Two questionnaires on research group leaders plus data on academic production and impact gathered from Thomson Reuters, ISI Web of Science (WoS), and the Social Science Citations Index (SSCI) and Arts & Humanities Citation Index (A&HCI). • Type of data: Quantitative
58	Motoyama (2014)	Japan	The focus of the paper is on how academic and corporate researchers at the frontline conduct advancement of 'knowledge' and 'technology' and develop such knowledge and technology in a long, complex process.	• Sample: Two cases of nanotechnology were studied. • Data collection: detailed archival search and interview • Type of data: qualitative
59	Styhre & Lind (2010)	Sweden	The objective of this paper is thus to show that the regime of the entrepreneurial university is creating new organizational forms within the institutional domain of higher education and research.	• Sample: ten research centers from UniTech (Average 3 interviews per center) • Data collection: interviews and participative observations. • Type of data: Qualitative
60	Lemos & Cario (2017)	Brezil	The overall objective of this study is to analyse the establishment and development of U–I interactions in Santa Catarina.	• Sample: 38 researchers and managers of technological innovation centers • Data collection: In depth interviews • Type of data: Qualitative
61	Mathies & Slaughter (2013)	USA and France	This study examines the associations between research funding and science corporation representation on university boards.	• Sample: only voting members of boards of trustees of the 26 private US AAU • Data collection: Data collected include university, trustee name, the name of the publicly traded corporations on which the trustee sits as a member of the board or boards of directors, and the NAICS code. • Type of data: Quantitative
62	Kruss et al. (2015)	Uganda, Nigeria, and South Africa	This chapter aims at examining the nature of university–industry interaction in distinct African contexts.	• Sample: (Nigeria: 139 manufacturing firms; Uganda: 36 SMEs, South Africa: based on national dataset from innovation survey. • Data collection: interviews and data from contextual studies • Type of data both quantitative and qualitative
63	Schiller & Lee (2015)	Korea, Malaysia, Thailand, China, and India	The aim of this chapter was to assess in a comparative way to what extent UILs are a meaningful vehicle for catch- up processes in five Asian latecomer and catch- up countries, to explain the differences in UILs among the five countries, and to give policy recommendations on the enhancement of UILs during catch- up processes.	The research used interviews, case studies, and quantitative and qualitative analysis using a questionnaire survey and in- depth interactions with policymakers and practitioners. Surveys were carried out in Korea, Malaysia, Thailand, China, and India.
64	Bjerregaard (2009)	Denmark	To examine the collaboration strategies employed by collaborating SMEs and university researchers for initiating and optimizing the process and outcome of R&D collaboration.	• Sample: 26 interviewees from 19 SMEs and 9 public University Departments • Data collection: Semi structured interviews

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#	Publication	Country concerned	Research Objective	Elements of methodology
				• Type of data: Qualitative
65	Jain et al. (2009)	USA	To investigate the sense-making that scientists engage in as part of their participation in technology transfer and postulate that this process involves a potential modification in their role identity.	• Sample: 20 scientists and 8 TTO staff • Data collection: Semi structured interviews • Type of data: Qualitative
66	Wright et al. (2007)	Belgium, France, Germany etc.	The book aims to filling the gap in understanding of the process of spin off creation and development in environments outside the high tech clusters of the US.	The book used various quantitative and qualitative data either collected by the authors of drawn from other researches.
67	Schoen et al. (2012)	Belgium, France, Germany, etc.	This paper presents a discussion on which combinations of four structural dimensions should yield viable configurations of TTOs. It also addresses the pros and cons of the four types of TTOs.	• Sample: 16 case studies of universities located in six European countries • Data collection: In depth face to face interview plus information from websites of universities and reports • Type of data: Qualitative
68	Boh et al. (2015)	USA	This study offers a thorough analysis of the university spinoff development process, focusing in particular on student involvement in the initial phases of these technology commercialization efforts and on the impact of the larger university ecosystem.	• Sample: 130 individuals including founders of forty-seven spinoffs, directors and staff of TTOs, Entrepreneurship Center Directors, faculty engaged in entrepreneurship education and students (or alumni) • Data collection: Interview • Type of data: Qualitative

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