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Barriers and facilitators of university-industry collaboration for research, development and innovation: a systematic review

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Abstract

Cooperation in research, development and innovation (RD&I) between universities or research institutes and industries plays a fundamental role in the economic development of a country. Industry benefits from state-of-the-art laboratories and technologies from academia, while institutes learn about business reality and market needs. Numerous barriers to the establishment and maintenance of these partnerships have been investigated and reported in the literature, but the information generated by these empirical studies is very fragmented and there is a need to consider the barriers systematically in order to clarify the topic. The aims of this systematic review were to analyze university-industry collaborations set up for the purpose of RD&I in an effort to recognize the barriers and facilitators of the process and to identify the approaches by which such barriers may be overcome. Following searches of the Scopus database and application of the exclusion criteria, 86 relevant articles were identified and submitted to bibliometric analysis. Subsequently, 75 articles were selected for in-depth content analysis, and the ideas embodied therein were presented in a structured and comprehensive manner. Barriers were evaluated according to three different theoretical perspectives, namely the triple helix and the entrepreneurial university, the relational social capital and value creation, and technology transfer and cultural differences. The facilitators were categorized as internal and external. The results obtained highlight the importance of fostering relational social capital and providing tax incentives to facilitate industry's pursuit of innovation through academia partnerships, and also show that collaborative barriers in RD&I may be overcome to some extent by starting with smaller projects and gradually increasing their complexity. Based on the findings outlined in this review, we propose various lines for future research.

Keywords University-industry cooperation · Collaboration · Barriers · Trust · Experience · Social proximity

Extended author information available on the last page of the article

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1 Introduction

Within the context of university-industry collaboration (UIC), universities and research institutes fulfill the same function since both have research, development and innovation (RD&I) as part of their mission (Fuentes and Dutrénit 2012). Private companies depend on partnership with such institutes to ensure competitiveness in the market place (Villani 2013), either through innovation produced directly or through the training of human resources (Galán-Muros and Plewa 2016). However, in order to leverage their development, companies often find it necessary to scour the world for appropriate innovation (Huston and Sakkab 2006). In addition, the high cost of sophisticated laboratory equipment, the difficulty of access to international research and development centers, and the risks associated with innovation tend to impose severe limitations on the investment of companies in RD&I (Dutta et al. 2020). According to these authors, it is essential that public policies foster innovation by supporting collaborative activities.

The importance of scientific knowledge generated by academic/research institutions in collaboration with the private sector is undeniable for the economic growth of a nation but, in less developed countries, diverse barriers may impede this type of cooperation (Atta-Owusu et al. 2021; Figueiredo and Fernandes 2020). Collaboration between highly qualified academics/researchers and professionals in private organizations and companies could boost local economies by combining all existing technical skills and capabilities (Helfat and Peteraf 2003). Examples of the impact of UICs on economic development have been examined by various authors (Bercovitz and Feldman 2006; Ford et al. 2012; Yu et al. 2021). However, emerging industries, unlike their mature counterparts, lack fully developed knowledge networks and have meager public funding for research projects, thus making cooperative processes somewhat difficult (Bodas Freitas et al. 2013).

In order for UICs to thrive, companies need to learn to work outside the boundaries of their organization and to develop capabilities to interact and cooperate with partners that have different characteristics, which is to say that they have to manage their relationships. Academics and their peers in industry will need to learn from experience throughout the partnership period, especially during the first interaction when participants discover the norms and culture of the disparate organizations, with the necessity to reconcile differences, to reach a common understanding and to build trust (Bruneel et al. 2010).

Successful UICs have engendered numerous innovations worldwide, with academia affording a source of creativity and young inventive talent (Siegel et al. 2003) and industry focusing on the development of new products, processes and services that not only improve the quality of human life but also generate financial returns (Hidalgo and Albors 2011). In this scenario, collaborators from universities or research institutes also enhance their view of the issues faced by companies, since problem solving requires the joint effort of those that create knowledge and those that provide the capital and resources (Figueiredo and Ferreira 2022).

Although numerous innovations have emerged from academic/industrial combinations, few studies have focused on the constraints and incentives of UICs and none have been identified that systematize the barriers and facilitators of UICs. Therefore, the present systematic review aimed to analyze the literature relating to UICs set up for the purpose of RD&I, with a view to identifying the barriers and facilitators of such collaborations and the main factors that contribute to overcoming the potential problems. The review was targeted at answering the key questions: (i) What barriers and facilitators influence academic/industrial collaboration in RD&I; and (ii) How are these barriers overcome by the participating organizations. In order to achieve this aim, we classified the literature according to three different theoretical frameworks, namely the triple helix model, the relational social capital concept, and technology transfer and cultural differences.

To the best of our knowledge, no previous systematic review has integrated bibliometric tools with content analysis in order to provide a structured and comprehensive understanding of the barriers and facilitators of UICs in RD&I and, in this sense, our review makes an original contribution. By synthesizing the existing literature and presenting a framework that interconnects different clusters of UIC barriers and facilitators, we have produced a comprehensive view of the UIC landscape that can inform future research and practice.

While previous studies have explored various aspects of UICs, few have analyzed systematically the factors that influence the success or failure of such partnerships. Nevertheless, reviews are available dealing with specific features related to UICs, including measurement and evaluation of technology transfer (Autio and Laamanen 1995), cooperation patterns and research agendas (Mascarenhas et al. 2018), and context perspectives of collaboration processes (Nsanzumuhire and Groot 2020). Whilst these studies have provided important insights into different facets of UICs, but they do not provide a comprehensive overview of the challenges and opportunities of UICs across multiple theoretical perspectives.

The present article is structured as follows: Sect. 2 presents a justification of the literature review in terms of the importance and the role of UICs, together with details of the types of UICs and the forms of collaboration encountered. Section 3 outlines the methodology employed in identifying, selecting and analyzing peer-reviewed articles in the Scopus database that focus on the barriers and facilitators of UCIs. The bibliometric analysis of these articles is described in Sect. 4 while, in Sect. 5, the contents of the selected articles are analyzed in depth by examining the barriers and facilitators of UIC from three different perspectives. Section 6 takes the form of an overall discussion about the barriers and facilitators of UIC, with conclusions, limitations and directions for research presented in Sect. 7.

2 Literature review

2.1 Importance and role of UICs

The topic of UICs is of increasing importance in literature dealing with economic development and innovation since it refers to interactions between universities and

industries in which both parties benefit from the transfer of knowledge, expertise or technology and from the application of research findings to practical problems, scientific questions or the creation of new research opportunities (Adams et al. 2001; Bodas Freitas et al. 2013; Figueiredo and Ferreira 2022). This type of partnership is a key driver of innovation and economic growth, in that it enables universities to leverage their expertise and resources to address practical problems and to develop new technologies while giving businesses access to cutting-edge research and development capabilities (Perkmann et al 2013).

In this context, Amaral et al. (2011) emphasized the role of university-industry linkages in promoting regional economic development, while Bruneel et al. (2010) identified several factors that diminish the barriers to UICs. According to Autio and Laamanen (1995), technology transfer from universities to industry is important in creating value and increasing innovation in firms, a view upheld by Feller et al. (2002) who found that universities play a significant role in technological innovation in industry. Overall, these studies suggest that UICs are crucial for promoting economic growth, innovation, and competitiveness.

The government plays a fundamental role in making UICs a reality, and many governments around the world have developed policies and initiatives to encourage such collaborations by supplying funding for joint research projects, offering tax incentives for research and development, and creating innovation hubs and technology parks (Amaral et al. 2011; Bastos et al. 2021). In their analysis of UICs in the context of European Framework Programmes, Caloghirou et al. (2001) noted that government policies have a significant impact on the nature and extent of collaboration between universities and industry. Bastos et al. (2021) also found that government policies and initiatives have played a key role in the growth of UICs over the past 50 years.

Additional important aspects of UICs are the motives and gains of such relationships, with benefits including access to new knowledge and technology, increased innovation and the creation of new products and services. Chryssou (2020) noted that university-industry interactions can help businesses overcome challenges related to innovation, such as the lack of resources or expertise, while Canhoto et al. (2016) identified the co-production of value in digital research projects involving collaboration between universities and industry. On the other hand, Alunurm et al. (2020) highlighted the barriers to UICs, such as different goals and values, lack of trust, and intellectual property rights issues. Addressing these barriers is crucial for maximizing the benefits of UICs.

2.2 Types of UICs and forms of collaboration

According to Perkmann and Walsh (2007), UICs vary considerably with respect to their collaborative relationships, but the most frequently types of interactions described in the literature are: employment of graduates by companies (Chryssou 2020; Schartinger et al. 2002), conferences or other events organized or sponsored by businesses and universities (Chryssou 2020; Schartinger et al. 2002), joint publications (Galán-Muros and Plewa 2016; Schartinger et al.

2002), informal meetings, conversations and communications (Chryssou 2020; Polt et al. 2001; Schartinger et al. 2002), joint supervision of PhD and Master degrees (Galán-Muros and Plewa 2016; Schartinger et al. 2002), training of company members (Chryssou 2020; Polt et al. 2001; Schartinger et al. 2002), movement of researchers between universities and companies (Chryssou 2020; Galán-Muros and Plewa 2016; Polt et al. 2001; Schartinger et al. 2002), sabbatical leave for university members to work in an industrial setting (Canhoto et al. 2016; Schartinger et al. 2002), collaborative research and joint research programs (Galán-Muros and Plewa 2016; Lee et al. 2010; Schartinger et al. 2002), lectures given at universities by company members (Schartinger et al. 2002), contract research and technology-related consulting (Chryssou 2020; Galán-Muros and Plewa 2016; Lee et al. 2010; Polt et al. 2001; Schartinger et al. 2002), use of university facilities by companies (Galán-Muros and Plewa 2016; Schartinger et al. 2002), licensing of university patents by companies (Chryssou 2020; Lee et al. 2010; Schartinger et al. 2002), purchase of prototypes developed at universities (Chryssou 2020; Schartinger et al. 2002), support in the education of undergraduate students (Chryssou 2020; Polt et al. 2001), use of intellectual property rights by public scientific organizations (Polt et al. 2001), and technology-driven start ups founded by researchers from public scientific organizations (Lee et al. 2010; Polt et al. 2001).

Considering the diversity of collaborative interactions, it is important to emphasize that the present study focuses exclusively on UICs established through formal agreements with the aim of cooperating in RD&I activities (Perkmann and Walsh 2007). The various types of research partnership described in the literature include: collaborative research (Caloghirou et al. 2001; Fontana et al. 2005; Ham and Mowery 1998; Link 1998; Link et al. 2002), research centers managed jointly by university and industry (Adams et al. 2001; Feller et al. 2002; Rea et al. 1997), and other types of joint ventures as described by Carayol (2003). A special type of collaboration exists when industries outsource research and consulting services to universities and, in this case, the roles and responsibilities of the parties involved, as well as the costs incurred, are set out in research contract agreements (Perkmann and Walsh 2007). However, in the opinion of these authors, university researchers have less academic freedom in this kind of interaction because the work develops according to contract, the clauses of which define the objectives and the outcomes to be achieved.

According to Lind et al. (2013), the ways in which partners cooperate may be classified into four categories as follows: (i) Distanced collaboration, in which industry is the main funding agency of research in an agreed area but is distant from the decisions of the academic researchers regarding the performance of the project: (ii) Translational collaboration, where industry is more involved, with strong interest in and support for the research agenda, but does not participate in the day-to-day research activities. Such projects are typically designed and performed in a manner suitable for publication, and the university is expected to be the main beneficiary of the research; (iii) Specified collaboration, in which the industrial partner specifies the task to be performed at the university leaving researchers little freedom to connect the work with their other research activities. This form of collaboration is analogous to problem solving or contract research; and (iv) Developed collaboration,

where both academic and industrial partners are engaged with research tasks considered relevant for both partners.

Based on knowledge of the types of UICs and the forms of research collaboration, we have examined the factors that influence the progress of these partnerships from different perspectives.

3 Methodology

This systematic review followed the rigorous research protocol suggested by Tranfield et al. (2003) and the bibliometric method adopted by Bastos et al. (2021), which employs a quantitative approach to the analysis of published research through citations, co-citations, authorship, co-authorship, bibliographic coupling, keywords and journals (Francisco 2011; Pinto et al. 2014; Prado et al. 2016). Literature searches were performed within the Scopus database since it covers a broad spectrum of subject areas that are multidisciplinary in nature (Bastos et al 2021; Mascarenhas et al. 2018). The bibliographic search within the database was carried out on 12th September 2022 and covered only peer-reviewed articles written in English without specifying the period of time for publication, although the results of the search covered the period from 1978 to 2022. Searches were performed according to the protocol described by Mascarenhas et al. (2018).

The complementary techniques of bibliometric and content analysis were combined in order to provide a comprehensive evaluation of the current literature on the researched topic (Carvalho et al. 2013). While bibliometrics assist in understanding publication patterns in the main databases, content analysis focuses on the research articles and helps in building the conceptual framework (Takey and Carvalho 2016).

An initial search of the titles, abstracts and keywords of peer-reviewed articles employed the search terms detailed in Fig. 1 linked by appropriate Boolean operators. Wit-de-Vries et al. (2019) have emphasized that the terminology used in the literature to describe collaborative research is inconsistent, mainly because of the heterogeneous viewpoints of the various authors, and this imposes a limit on database searches. In the present case, a large number of articles ($n = 3391$) were retrieved when the terms "university" hyphenated with "company", "industry", "firm", "business" or "enterprise" were used, but the number was reduced to 222 when the filtering terms "barriers", "facilitators", "obstacles" or "motivators" were added. Furthermore, the number of articles decreased to 135 by limiting the subject area to "business, management and accounting" and "economics, econometrics and finance". After reading the titles, abstracts and keywords of these articles, a further selection was performed by excluding those not covering UICs and those not focusing on barriers and facilitators of collaboration, resulting in 86 articles for submission to bibliometric and content analysis (Fig. 1).

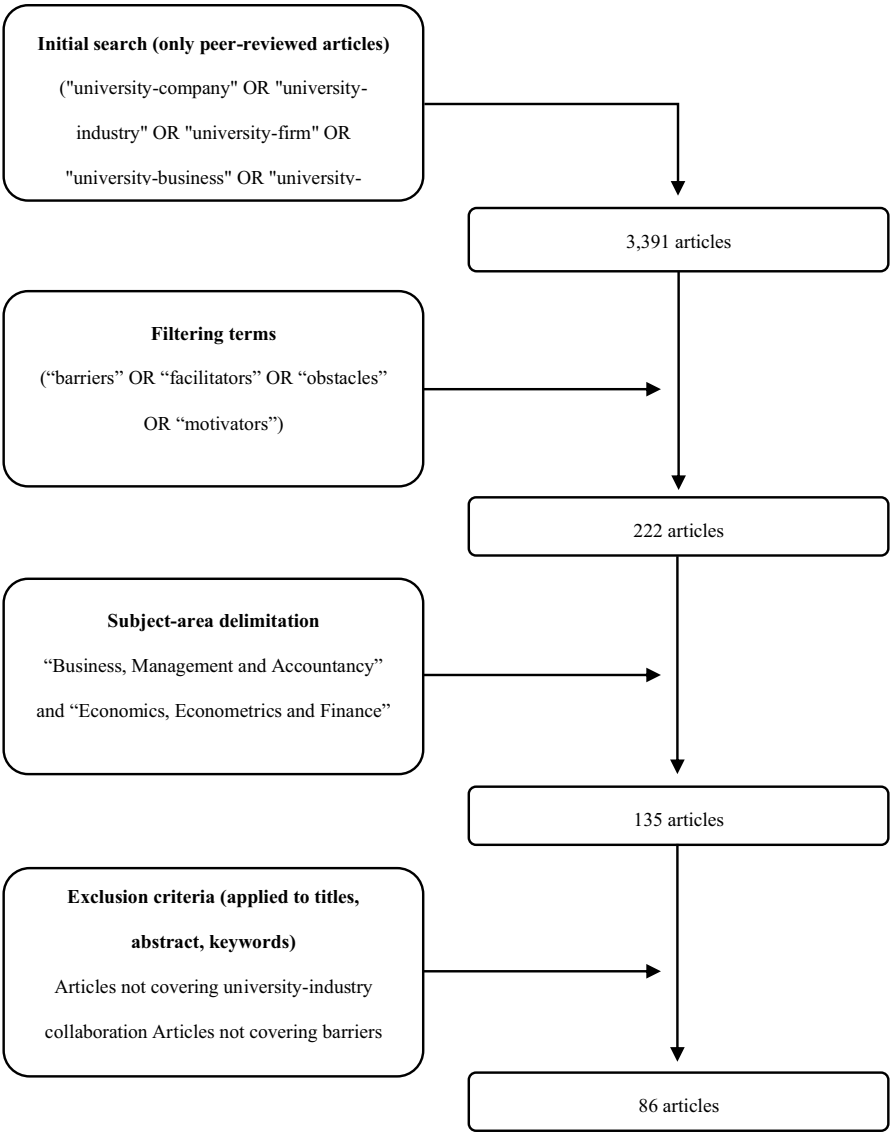

Fig. 1 Literature search protocol

4 Bibliometric analysis

Bibliometric (quantitative) data were analyzed and bibliometric networks visualized using Bibliometrix/Biblioshiny version 3.1.4 (available in the RStudio platform version 1.4.1106) and VOSviewer version 1.6.16. Qualitative data were analyzed using MaxQda 2022 software and suggestions proposed by Figueiredo and

Ferreira (2022). Bibliographic coupling was also performed since this approach is considered superior to other methods (Boyack and Klavans 2010) and affords more precise grouping of articles. Bibliographic coupling also helps in the analysis of similarities between articles as identified by their strength of connection revealed by citation analysis (Figueiredo and Ferreira 2022).

The scientific literature on UIC has expanded considerably in the last ten years, with a peak in publications occurring in 2020 and 2021. The temporal evolution of articles dealing with UICs and their barriers and facilitators (Fig. 2) reveals particularly strong growth since 2015. Thus, among the 135 articles selected prior to the application of exclusion criteria, 30 were published before 2010 while 105 were published within the period 2010–2022.

Economic crises and cuts in research funding have forced research institutions, especially those funded by governments, to seek partnerships in order to finance their RD&I projects (Czerwińska-Lubszczyk et al. 2020; Muscio and Vallanti 2014). At the same time, research related to collaboration processes has tended to increase, especially those related to COVID 19 and climate change (Tootell et al. 2021).

Peer-reviewed journals were ranked according to the number of times the UIC articles published by them were cited in the literature, and the top ten are listed in Fig. 3. The average citation number of the listed journals was 262 with *Research Policy* at the top with 750 citations. While *Industry and Higher Education* and *Journal of Technology Transfer* published the highest numbers of UIC articles ($n = 9$ and 8, respectively), these journal were classified with different impact levels according to the evaluation criteria of SCImago Journal and Country Rank (2021) for the Business Management and Accounting subject area, with the first in Q2 (H-index 27) and the second in Q1 (H-index 88).

Bibliographic coupling of the final 86 articles, with at least zero citations and 10 documents per cluster (Boyack and Klavans 2010), resulted in the identification of 75 articles with links to three clusters (Fig. 4). The diameters of the circles represent articles with the highest number of citations, with emphasis on the studies by

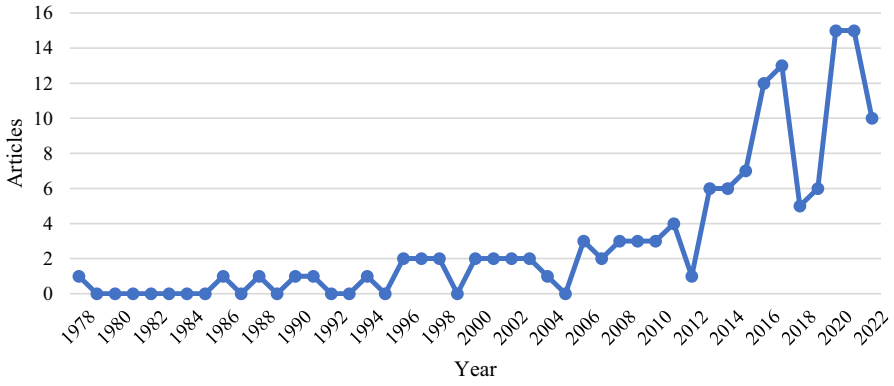

Fig. 2 Evolution in the number of articles published about university-industry collaborations during the period 1978–2022

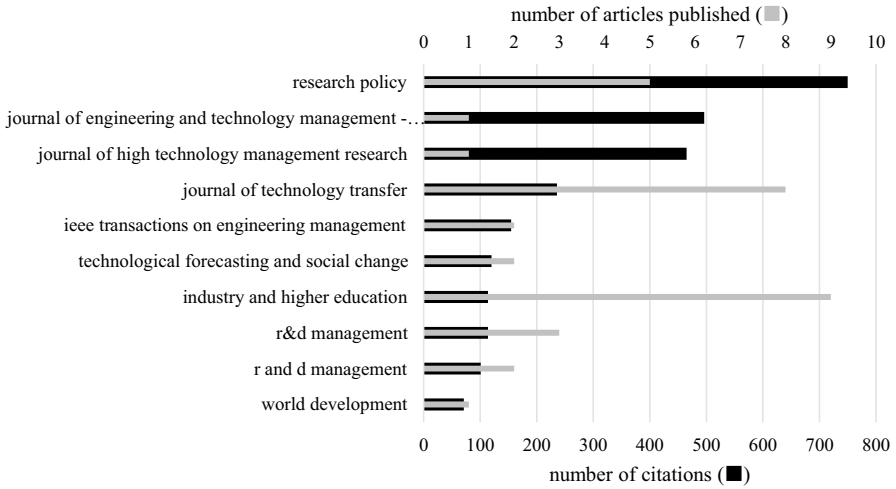

Fig. 3 Journals that received the largest number of citations for articles concerning university-industry collaborations (Filled square) and the number of articles each published on this topic (shaded square) during the period 1978–2022

Bruneel et al. (2010) and Siegel et al. (2003, 2004). The 75 articles so-identified were subjected to in-depth analysis and the findings classified to explain the barriers and facilitators of UICs according to the following perspectives: (i) the triple helix model and the entrepreneurial university; (ii) relational social capital and social value creation; and (iii) technology transfer and cultural differences.

5 Content analysis

Content analysis of articles on UICs poses a particular challenge by virtue of the varied factors that affect such collaborations and the diverse contexts and perspectives that researchers have employed in their studies, many of which use different terminologies. In order to address this issue, we undertook a systematic analysis of the articles within the three different perspectives (Clusters 1–3) that emerged from the bibliographic coupling and identified the barriers and facilitators separately in the context of these perspectives.

5.1 The triple helix concept and the entrepreneurial university

The 34 articles in Cluster 1 (Table 1) focus on the determinants of UICs through the triple helix model, which extends the traditional basic roles of university by defining the entrepreneurial university. These articles support the idea that the economic development of society is achieved through innovation, which is driven, in turn, by interactions between three entities (university, industry and

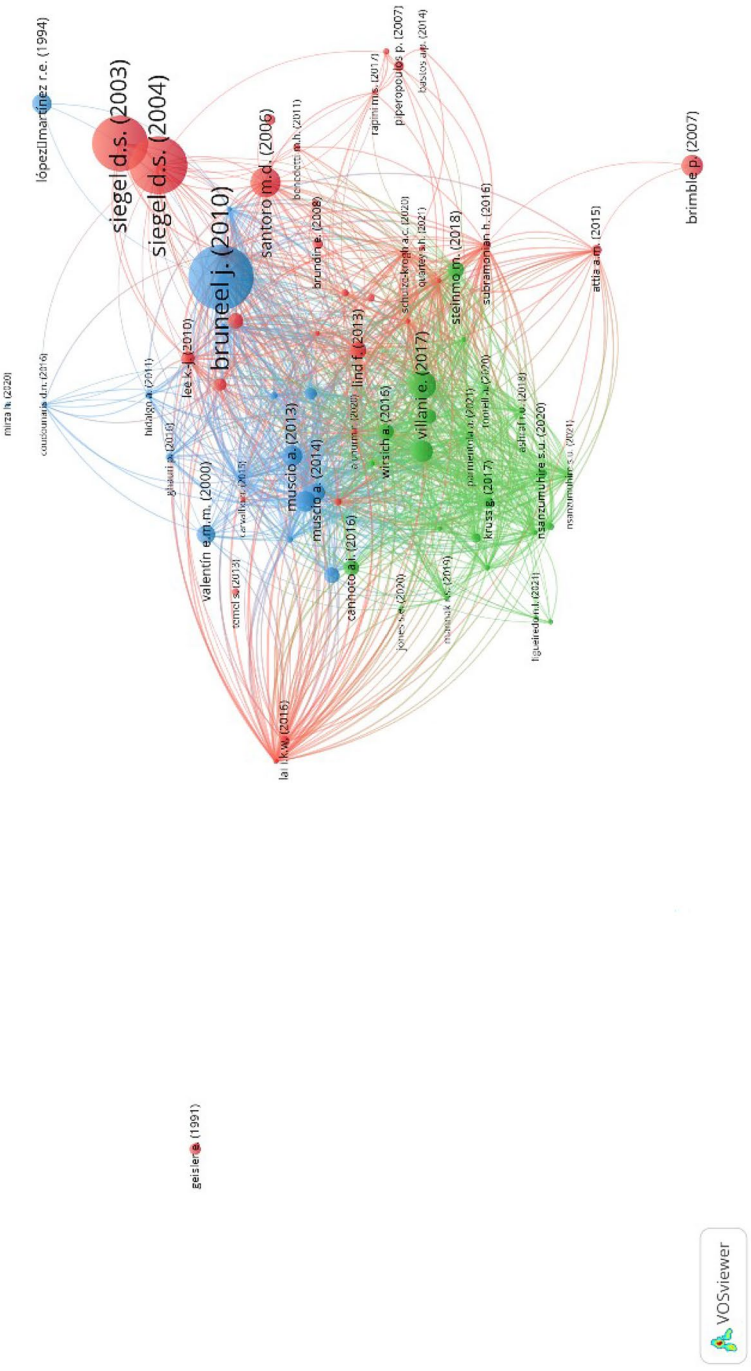

Fig. 4 Citation-based bibliographic coupling map showing the network of articles

Table 1 Articles assembled in Cluster 1

Authors/years	Titles
Alunurm et al. (2020)	The relative significance of higher education–industry cooperation barriers for different firms
Amaral et al. (2011)	Building an entrepreneurial university in brazil: The role and potential of university–industry linkages in promoting regional economic development
Attia (2015)	National innovation systems in developing countries: Barriers to university–industry collaboration in Egypt
Bastos et al. (2014)	University-Enterprise partnerships in the Brazilian Amazon: obstacles, dilemmas and challenges
Benedetti and Torkomian (2011)	An analysis of the influence of University-Enterprise cooperation on technological innovation
Brimble and Doner (2007)	University-Industry linkages and economic development: The case of Thailand
Brundin et al. (2008)	Triple helix networks in a multicultural context: Triggers and barriers for fostering growth and Sustainability
Carvalho et al. (2015)	Cooperation management in integration of university-industry-government: Facilitators factors triple Helix
Chryssou (2020)	University–industry interactions in the Sultanate of Oman: Challenges and opportunities
Gattringer et al. (2014)	Network-structured university-industry-collaboration: Values for the stakeholders
Geisler (1986)	The role of industrial Advisory Boards in technology transfer between universities and industry
Geisler et al. (1991)	Toward a conceptual model of cooperative research: Patterns of development and success in university-industry alliances
Gerbin and Drnovsek (2016)	Determinants and public policy implications of academic-industry knowledge transfer in life sciences: a review and a conceptual framework
Lai and Lu (2016)	How to improve the university–industry collaboration in Taiwan's animation industry? Academic vs. industrial perspectives
Lee (2011)	From interpersonal networks to inter-organizational alliances for university-industry collaborations in Japan: The case of the Tokyo Institute of Technology
Lee et al. (2010)	Formal boundary spanning by industry liaison offices and the changing pattern of university-industry cooperative research: The case of the university of Tokyo
Lind et al. (2013)	Exploring university-industry collaboration in research centres
Mildahn and Schiller (2006)	Barriers for the university-industry knowledge transfer in newly industrialised countries—An empirical analysis of the regional innovation system of Bangkok
Piperopoulos (2007)	Barriers to innovation for SMEs: empirical evidence from Greece
Quartey and Oguntoye (2021)	Understanding and promoting industrial sustainability in Africa through the triple helix approach: a conceptual model and research propositions
Rapini et al. (2017)	Obstacles to innovation in Brazil: The lack of qualified individuals to implement innovation and establish university–firm interactions

Table 1 (continued)

Authors/years	Titles
Razak and White (2015)	The Triple Helix model for innovation: A holistic exploration of barriers and enablers
Ribeiro and Nagano (2021)	On the relation between knowledge management and university-industry-government collaboration in Brazilian national institutes of science and technology
Salimi and Rezaei (2018)	University Relationship Management
Santoro and Bierly (2006)	Facilitators of Knowledge Transfer in University-Industry Collaborations: A Knowledge-Based Perspective
Santos and Torkomian (2013)	Technology transfer and innovation: The role of the Brazilian TTOs
Schulze-Krogh and Calignano (2020)	How Do Firms Perceive Interactions with Researchers in Small Innovation Projects? Advantages and Barriers for Satisfactory Collaborations
Siegel et al. (2003)	Commercial knowledge transfers from universities to firms: Improving the effectiveness of university-industry collaboration
Siegel et al. (2004)	Toward a model of the effective transfer of scientific knowledge from academicians to practitioners: Qualitative evidence from the commercialization of university Technologies
Silva et al. (2020)	Internal barriers to innovation and university-industry cooperation among technology-based SMEs in Brazil
Subramonian and Rasiah (2016)	University–industry collaboration and technological innovation: sequential mediation of knowledge transfer and barriers in automotive and biotechnology firms in Malaysia
Temel and Glassman (2013)	Examining university-industry collaboration as a source of innovation in the emerging economy of Turkey
Vega-Jurado et al. (2015)	Integrating technology, management and marketing innovation through open innovation models
Wallin et al. (2014)	Bridging the gap between university and industry: Three mechanisms for innovation efficiency

government) known as the triple helix framework (Leydesdorff and Etzkowitz 1998). Etzkowitz (2003) stressed the importance of the university as a driving force of innovation, the so-called entrepreneurial university, the role of which is not only to create knowledge and train new professionals but also to generate enterprises, particularly those that are technology-based. According to Amaral et al. (2011), for this type of innovation to occur, proactive leaders with entrepreneurial skills are required to promote interaction between the various players. Alunurm et al. (2020) have described the barriers and factors that interfere in the relationship between academic and industrial partners, without making it clear which barriers affect the different partners. This is particularly significant considering that the establishment of UICs has been encouraged by all components of the triple helix, but most especially by governments and universities.

Razak and White (2015) have suggested that there are three types of barriers related to the triple helix model, namely: (i) relationship issues arising from the different work cultures of the partners; (ii) university issues associated with perception

of the status and capabilities of the university; and (iii) political issues related to the integration of work activities, knowledge development and the commercialization and/or protection of intellectual property. At the organizational level, these barriers can be considered in the strategic, tactical and operational dimensions (Wallin et al. 2014). The strategic dimension concerns the difference between partners regarding the time standpoint, in that universities take a long-term view of research while industry has a short-term perception for research and implementation. Other authors have also identified this barrier (Alunurm et al. 2020; Bruneel et al. 2010; Galán-Muros and Plewa 2016; Ghauri and Rosendo-Rios 2016; Mannak et al. 2019; Rapini et al. 2017; Villani 2013) and recommend that the issue be taken into account at the planning stage of collaborative research. The tactical dimension relates to the need for participants from different organizations and cultures to meet together for collaborative activities, such as conceptualization and brainstorming, without any of the parties dominating. The operational dimension addresses the solution of unforeseen problems, the management of unpredicted situations and the competent communication of ideas in order to create innovations.

Although the size of the company influences the likelihood of cooperation, whether such influence is positive or negative remains contentious. While Alunurm et al. (2020) do not believe that small firms are less likely to cooperate, the large majority of authors offer opposing views (Cohen et al. 2002; Laursen and Salter 2004; Tether 2002). These authors also claim that barriers can arise at any time during the collaboration process, but emphasize that impediments related to social capital or perception can block companies seeking collaboration with universities from the very beginning. A controversial point relating to social barriers concerns the prestigious position of academics in Japanese national universities, which, according to Lee et al. (2010), is an obstacle for cooperative research projects because it inhibits aggressive commercial demands from industrial partners. In such cases, strong mediation by third parties may be required to align the interests of private partners and university researchers.

Implementation of the triple helix model can be facilitated by government as part of its fundamental role in the regional development of innovation. Amaral et al. (2011) stated that it is necessary to increase the complexity of RD&I infrastructure and to transfer power to regional bodies that can encourage members of the triple helix to engage in joint innovation projects, create innovation networks and develop industrial creativity. For this to occur, universities must be proactive in their entrepreneurial mission (Schulze-Krogh and Calignano 2020). However, Amaral et al. (2011) claimed that proactive behavior was not observed in a study involving two Brazilian universities, both of which tended to adopt a passive or reactive role in the interaction process. Despite these examples, the universities are becoming increasingly more involved with their local communities by contributing to regional economic development and encouraging relations with industry (Lind et al. 2013). The concept of an entrepreneurial and proactive university is not recent (Etzkowitz 1983), but has evolved gradually during the last four decades and progressed as new successful cases have emerged (Brundin et al. 2008; Wallin et al. 2014).

In France, a series of systemic failures has forced companies to adopt a collaborative strategy with other organizations in order to deal with the most relevant

barriers to innovation, namely those relating to finance and knowledge (Antonioli et al. 2017). In the case of knowledge barriers, there is a strong impetus for cooperation with public research institutes and universities. On the other hand, Silva et al. (2020) reported that, in Brazil, attitudes to overcoming barriers were somewhat different. Thus, in manufacturing industries, knowledge barriers were only moderately associated with the possibility of cooperation with universities and public research institutes, while in knowledge-intensive service companies, financial barriers were strongly associated with the possibility of cooperation. These findings do not imply that collaboration is unimportant in developing countries, but that it is not a critical issue in the perception of small- and medium-size companies. It is noteworthy how the use of cooperation as a strategy to overcome innovation barriers varies from company to company, depending on the type of activity, size and geographic location, and between developed and developing countries.

5.2 Relational social capital and social value creation

The 24 articles in Cluster 2 (Table 2) consider the barriers and facilitators of UICs from the perspective of social capital and value creation. Social capital theory contends that trust between partners in a collaborative relationship can lead to the development and accumulation of human capital and exert a strong positive influence on the creation and transfer of knowledge. Bloedon and Stokes (1994) had already stated that collaborative processes demand the face-to-face presence of people, even though electronic forms of communication were emerging at that time. Moreover, successful collaboration requires constant interaction with the formation of professional networks and participation in workshops, seminars and informal brainstorming sessions. Social capital is intangible and formed by relationships between people (human capital) with individual skills and knowledge (Coleman 1988). The presence of social capital means broad trust and brings with it the possibility of teamwork with effective results.

The cognitive and relational dimensions of social capital have been analyzed by Steinmo and Rasmussen (2018). According to this viewpoint, companies may succeed in collaborative interactions with universities without the need to have high cognitive social capital if there is sufficient relational social capital at the beginning of the collaboration and cognitive social capital is developed during the partnership. This idea supports the findings of Muscio and Pozzali (2013) who studied barriers to UICs imposed by cognitive distance, which is understood as the difference in sets of basic values, norms and mental models. These authors concluded that cognitive distance does not impede collaboration but makes interactions more difficult. Actually, cognitive distance is similar to the orientation barriers described previously by Bruneel et al. (2010). Along the same lines, Tootell et al. (2021) conducted a study with the objective of understanding the barriers and facilitators for the co-creation of knowledge based on affective trust (characterized by concern for the partner in a more emotional manner) and cognitive trust (characterized by reliance on the skills and competences of the partner). The results of this study indicated that cognition-based trust is essential for building relationships and corroborated the findings of

Table 2 Articles assembled in Cluster 2

Authors/years	Titles
Alexander et al. (2020)	University–industry collaboration: using meta-rules to overcome barriers to knowledge transfer
Alibekova et al. (2019)	Determinants of technology commercialization ecosystem for universities in Kazakhstan
Ashraf et al. (2018)	Collaborative university-industry linkages in Pakistan
Bilić et al. (2021)	Academic entrepreneurship in post-transition country—Case study of Croatia
Canhoto et al. (2016)	The co-production of value in digital, university–industry R&D collaborative projects
Czerwińska-Lubszczyk et al. (2020)	Cooperation of universities with business in Poland and the USA—Perspective of scientific environment
Figueiredo and Fernandes (2020)	Cooperation university–industry: A systematic literature review
Jones and Coates (2020)	A micro-level view on knowledge co-creation through university-industry collaboration in a multi-national corporation
Kruss and Visser (2017)	Putting university–industry interaction into perspective: a differentiated view from inside South African universities
Kunttu and Neuvo (2019)	Balancing learning and knowledge protection in university-industry collaborations
Lopes and Lussuamo (2021)	Barriers to university-industry cooperation in a developing region
Mannak et al. (2019)	A temporal perspective on repeated ties across university-industry R&D consortia
Nsanzumuhire and Groot (2020)	Context perspective on University-Industry collaboration processes: A systematic review of literature
Nsanzumuhire et al. (2021)	Understanding the extent and nature of academia-industry interactions in Rwanda
Parmentola et al. (2021)	Exploring the university-industry cooperation in a low innovative region. What differences between low tech and high tech industries?
Sjöö and Hellström (2019)	University–industry collaboration: A literature review and synthesis
Steinmo and Rasmussen (2018)	The interplay of cognitive and relational social capital dimensions in university-industry collaboration: Overcoming the experience barrier
Suzuki (2017)	International university–industry linkage: Impact on firm technological performance
Tootell et al. (2021)	Knowledge creation in complex inter-organizational arrangements: understanding the barriers and enablers of university-industry knowledge creation in science-based cooperation
Van Rijnsoever and Hessels (2021)	How academic researchers select collaborative research projects: a choice experiment
Villani et al. (2017)	How intermediary organizations facilitate university–industry technology transfer: A proximity approach
Wirsich et al. (2016)	Effects of University–Industry Collaboration on technological newness of firms
Wit-de-Vries et al. (2019)	Knowledge transfer in university–industry research partnerships: a review

Table 2 (continued)

Authors/years	Titles
Zammar et al. (2017)	University-industry interface management: guidelines derived from a case study

Steinmo and Rasmussen (2018) to some extent. Accordingly, Tootell et al. (2021) stated that the initiation and continuity of personal relationships for the creation of knowledge requires people who have mutual confidence based on both cognition and affection.

Trust and communication play key roles in overcoming the objective and cognitive differences between the partners of a UIC (Wit-de-Vries et al. 2019), a process that may be facilitated by the involvement of mediators such as technology transfer offices or university-industry liaison offices. According to Alexander et al. (2020), the relationships in long-term partnerships should be prioritized because the combination of different skills and abilities is important for the delivery of consistent results, especially in knowledge creation (Canhoto et al. 2016). The longer the life cycle of the project, the greater are the benefits for the partnership, especially in relation to research support, pedagogical backup and entrepreneurial opportunities (Lee 2000). Start-ups, along with small- and medium-size companies, tend to engage in short-term projects of three years or less, whereas large companies develop long-term projects that may have life times of more than 5 years in the case of consortia of joint ventures.

One of the critical barriers to the collaborative process is the difference between contributors in a RD&I project regarding the perception of the goals to be achieved, especially when one partner is unaware of the expectations or values of the other (Canhoto et al. 2016). For example, the industrial partner may believe that its academic counterpart wants to know how industry works and to obtain useful information for teaching activities, whilst what the academic partner really wants is to present ongoing research and demonstrate its potential impact to the industrial collaborator. Canhoto et al. (2016) proposed five practical principles that could facilitate the successful development of collaborative RD&I. The first principle is that the academic partner should share research-based information in a manner that is accessible to industry, while the second is to employ a common language with which everyone involved in the project can easily identify and understand. The third principle advances the use of intermediary organizations as facilitators or translators between industry and university researchers, whereas the fourth is related to trust between partners and the need for mechanisms that support joint learning. The final principle is that the teams should comprise dedicated individuals with proactive attitudes towards collaboration and innovation, strong social and communication skills, and complementary technical expertise. Ideally, all teams should receive financial or emotional/symbolic incentives for their efforts.

Table 3 Articles assembled in Cluster 3

Authors/years	Titles
Bruneel et al. (2010)	Investigating the factors that diminish the barriers to university-industry collaboration
Calvo et al. (2019)	Analysis of the researcher's motivators to collaborate with firms as drivers of the triple helix dynamics
Coudounaris (2016)	Moderating factors and effects: Different perceptions of university researchers in Sweden
Daniel and Alves (2020)	University-industry technology transfer: the commercialization of university's patents
Filippetti and Savona (2017)	University–industry linkages and academic engagements: individual behaviours and firms' barriers. Introduction to the special section
Galán-Muros and Plewa (2016)	What drives and inhibits university-business cooperation in Europe? A comprehensive assessment
Ghauri and Rosendo-Rios (2016)	Organizational cross-cultural differences in the context of innovation-oriented partnerships
He et al. (2021)	Asymmetries between partners and the success of university-industry research collaborations
Hidalgo and Albors (2011)	University-industry technology transfer models: An empirical analysis
López-Martínez et al. (1994)	Motivations and obstacles to university industry cooperation (UIC): a Mexican case
Mirza et al. (2020)	Barriers to university-industry collaboration in an academic university department in London, United Kingdom
Muscio and Pozzali (2013)	The effects of cognitive distance in university-industry collaborations: Some evidence from Italian universities
Muscio and Vallanti (2014)	Perceived Obstacles to University–Industry Collaboration: Results from a Qualitative Survey of Italian Academic Departments
Resende et al. (2013)	BTP—Best Transfer Practices. A tool for qualitative analysis of tech-transfer offices: A cross cultural analysis
Simachev et al. (2014)	R&D cooperation between russian firms and research organizations: Is there a need for state assistance?
Valentín (2000)	University—industry cooperation: a framework of benefits and obstacles
Villani (2013)	How external support may mitigate the barriers to university-industry collaboration

5.3 Knowledge transfer and cultural differences

The 17 articles in Cluster 3 (Table 3) encompass papers that discuss technology transfer and cultural differences. Knowledge or technology transfer has been defined as the "*the process by which knowledge about doing useful things contained in one organized environment is put to use in another organizational context*" (Bloedon and Stokes 1994, p. 44). Another definition of technology transfer is "*the intentional, goal-oriented interaction between two or more social entities, during which the pool of technological knowledge remains stable or increases through the transfer of one or more components of technology*" (Autio and Laamanen 1995, p. 648). These

concepts make it clear that technology transfer occurs where there is collaboration, but, where innovation is driven by collaboration, there are bound to be challenges.

One of the main barriers to technology transfer is the cultural difference between companies and universities since both have different normative codes (Valentín 2000). Academics enjoy the freedom to publish and disseminate the knowledge they have generated, from which they acquire professional prestige for the quality of their research. In contrast, their industrial counterparts strive to erect boundaries in order to protect the knowledge by privacy and secrecy. In addition, the two organizations differ with respect to the pace of research in that academic projects tend to develop slowly whereas those in industry have faster time-lines.

Other barriers to collaboration are mainly associated with market orientation, time frames and corporate flexibility (Ghauri and Rosendo-Rios 2016), which negatively influence partners in different multicultural sectors and undermine the continuity of partnership. According to Galán-Muros and Plewa (2016), the barriers to UICs relate to: (i) connections—difficulties of identifying suitable contact people to initiate discussions, and lack of awareness of potential partner organizations; (ii) funding—financing constraints in collaborative research whether through university support, government grants or industrial investment; (iii) organizational culture—different motivations, modes of communication, time horizons, and levels of bureaucracy; and (iv) internal organizational characteristics -companies require confidentiality of their innovations and technological improvements and fear the disclosure of such information.

Bruneel et al. (2010) have examined two other categories of obstacles of collaborative research, namely: (i) orientation-related barriers—university research is orientated towards pure science and planned according to a long-term schedule, which may give rise to a lack of mutual understanding between academia and industry; and (ii) transaction-related barriers—industrial liaison offices have unrealistic expectations, absence or low profile of industrial liaison offices in universities, conflicts regarding royalties from patents or other intellectual property rights, concerns about confidentiality, rules and regulations imposed by universities or government agencies. According to these authors, orientation barriers are easier to overcome than transaction barriers, since the former depend on understanding between the parties while the latter are related to the external and/or regulatory environment, the effects of which are more difficult to mitigate.

5.4 Classification of barriers and facilitators

The three clusters identified in the literature review reveal a complex interplay of factors that contribute to the success or failure of UICs. In order to achieve a comprehensive understanding of these factors, it is essential to integrate the findings from each cluster and consider the barriers and facilitators as interconnected elements. This section aims to provide a synthesis of the critical barriers and facilitators across the three clusters.

The barriers to UICs comprise all obstacles that impede the full success of the cooperation. Some authors, for example Bruneel et al. (2010) and Hall et al.

(2003), believe that the main barriers are related to intellectual property, while others include the degree of uncertainty (risk) of the project, excessive bureaucracy (Segatto-Mendes and Sbragia 2002) and meeting targets and deadlines (Benedetti and Torkomian 2011), with the latter having a negative impact on the speed of innovation.

In order better to understand the complexity of the situation, a number of attempts have been made to categorize the barriers to UICs. Thus, Van Dierdonck and Debackere (1988) provided a comprehensive categorization of barriers, while Nsanzumuhire and Groot (2020) used a more detailed classification and Bruneel et al. (2010) adopted a two dimensional (dualistic) categorization of barriers to UICs. Table 4 summarizes the main classification and categories of barriers found in the literature, while Table 5 presents an expanded classification based on the categories listed in Table 4. The systematization of the barriers should contribute towards planning the actions necessary to overcome the obstacles between academia and industry and attaining fruitful interactions.

Facilitators of collaborative processes are essential in overcoming the barriers that emerge in all phases of partnership. The satisfaction of companies that participate in UICs is greater when there is appreciable interaction and mutual learning during the course of the project (Schulze-Krogh and Calignano 2020). Moreover, fruitful interaction and mutual learning improve experience, and this is another factor proposed by Bruneel et al. (2010) for strengthening long-lasting collaborations. Indeed, when companies meet their research or commercial expectations, fresh opportunities arise for the continuation of existing RD&I projects or planning new ones.

Unfortunately, the literature regarding the categorization of facilitators of UICs is somewhat limited. One classification proposed by Villani et al. (2017) considered how intermediary organizations make UICs more effective by increasing cognitive, organizational, geographic and social proximity. A simple classification proposed by Salimi and Rezaei (2018) categorizes facilitators as: (i) internal—related to the scientific field of the company; and (ii) external—related to the external characteristics of the environment. Table 6 presents a summary of the facilitators of UICs constructed based on this simplified classification.

6 Discussion

The conceptual framework of this study (Fig. 5) is centered on the three identified clusters that illustrate the breadth of the topic relating to barriers and facilitators of RD&I by UICs. A summary of each cluster is presented and their possible interconnections are discussed.

Alongside the traditional functions of universities to provide higher education and professional training, they must also strive to fulfill their entrepreneurial mission of creating innovation, even though there is an underlying fear of "giving away" technology to the private sector (Siegel et al. 2003). Nevertheless, the innovative and knowledge-producing roles of the university clearly influence industrial innovation

Table 4 Main classification of barriers to university-industry collaboration defined in the literature

Categories	Brief description	References
Comprehensive		
Cultural	Distinct social, cultural and economic roles that generate a lack of mutual understanding	Van Dierdonck and Debackere (1988)
Institutional	Differences in rules and values, lack of cooperation structure	
Operational	Lack of experience, resources, conflicts of interest regarding intellectual property rights, research time-line, etc	
Detailed		
Misalignment	Lack of alignment between what is done in academia and what is needed in industry	Nsanzumuhire and Groot (2020)
Motivation	Lack of incentive for university scientists and lack of confidence of industrial researchers in academia	
Capability	Lack of skills and structure necessary for cooperation	
Governance	Lack of management, decision, support and communication	
Contextual	Regional characteristics, risk, distances and passive environment	
Dualistic		
Orientation	Divergent goals and lack of mutual understanding	Bruneel et al. (2010)
Transaction	Additional costs, bureaucracy, rules and regulations	

Table 5 Expanded classification of barriers to university-industry collaborations (based on Table 4)

Categories			Barriers	References
Comprehensive	Detailed	Dualistic		
Cultural	Misalignment	Orientation	Differences in objectives between the parties. University research is highly oriented towards pure science. Differences between research and enterprise environments. Low level of application of RD&I production to companies activities. Disparity between university knowledge and the demands of companies. Failure to recognize business value	Alunurm et al. (2020); Amaral et al. (2011); Brundin et al. (2008); Bruneel et al. (2010); Carvalho et al. (2015); Schulze-Krogh and Calignano (2020); Subramonian and Rasiah (2016); Tootell et al. (2021)
			Differences in positions and time options between the industry and academia. Industry delays the dissemination of research results	Alunurm et al. (2020); Amaral et al. (2011); Benedetti and Torkomian (2011); Bruneel et al. (2010); Carvalho et al. (2015); Chryssou (2020); Muscio and Pozzali (2013); Wallin et al. (2014)
			Lack of mutual understanding about expectations/priorities	Bruneel et al. (2010); Muscio and Pozzali (2013)
Cultural	Capability	Orientation	Inequitable interactions and low initial social investment. Research institutes prefer to work alone	Schulze-Krogh and Calignano (2020); Tootell et al. (2021)
Cultural	Contextual	Orientation	Low level of knowledge about the benefits that can arise from cooperative interactions. Poor attitude towards the partner. Perception that acedemia is not sufficiently competent for cooperation. Perception of academic status and capabilities	Alunurm et al. (2020); Amaral et al. (2011); Chryssou (2020); Razak and White (2015); Tootell et al. (2021)
Cultural	Contextual	Transaction	Perception that intellectual property is not important in the particular research field	Muscio and Pozzali (2013)
Cultural	Misalignment	Orientation	The research is not linked to industrial interests/needs. Leave of absence of the researcher in relation to the activities of the industry	Carvalho et al. (2015); Muscio and Pozzali (2013)
Cultural	Misalignment	Transaction	Universities need publications	Schulze-Krogh and Calignano (2020)
			Potential conflicts with industry regarding patents	Bruneel et al. (2010); Geisler (1986); Muscio and Pozzali (2013); Razak and White (2015)

Table 5 (continued)

Categories			Barriers	References
Comprehensive	Detailed	Dualistic		
Cultural	Governance	Orientation	Collaboration with people from different organizations	Razak and White (2015); Ribeiro and Nagano (2021); Tootell et al. (2021); Wallin et al. (2014)
Cultural	Motivation	Orientation	University researchers are not motivated to cooperate. Absence of incentives and working conditions. Absence of mechanisms to encourage cooperation	Alunurm et al. (2020); Amaral et al. (2011); Carvalho et al. (2015); Chryssou (2020))
			Collaboration is detrimental to career progress	Muscio and Pozzali (2013)
			Collaborations conflict with teaching/research duties	Muscio and Pozzali (2013)
Institutional	Capability	Transaction	Lack of planning and infrastructure	Brundin et al. (2008); Chryssou (2020); Schulze-Krogh and Calignano (2020)
			Absence or low profile of technology transfer offices in universities. Absence of mediators	Amaral et al. (2011); Bruneel et al. (2010); Muscio and Pozzali (2013)
Institutional	Contextual	Orientation	Ignorance of legislation and mechanisms for financing innovation and university-industry relations	Amaral et al. (2011)
			Lack of appropriate policies to integrate knowledge-related activities	Razak and White (2015)
Institutional	Contextual	Transaction	Inconsistent support from political leaders	Brimble and Doner (2007)
			Socioeconomic reality (tax, legislation and the cost of doing business in the country)	Ribeiro and Nagano (2021)
			Difficulty in finding innovative companies	Muscio and Pozzali (2013)
			Lack of government funding. Lack of financial resources in general	Alunurm et al. (2020); Muscio and Pozzali (2013)
			Professional research networks include few or no companies	Muscio and Pozzali (2013)
Institutional	Misalignment	Transaction	Industrial liaison offices tend to exaggerate the results of research or to have unrealistic expectations	Bruneel et al. (2010)

Table 5 (continued)

Categories			Barriers	References
Comprehensive	Detailed	Dualistic		
Institutional	Governance	Orientation	Lack of appropriate mechanisms of communication and collaboration	Chryssou (2020)
Institutional	Governance	Transaction	Bureaucracy	Amaral et al. (2011); Canhoto et al. (2016); Carvalho et al. (2015); Ribeiro and Nagano (2021); Tootell et al. (2021)
			Perception of business risks	Tootell et al. (2021)
			High staff turnover and poor industrial strategy	Muscio and Pozzali (2013)
			Lack of established procedures in the university for collaboration	Muscio and Pozzali (2013)
			Rules set by universities or government funding schemes	Bruneel et al. (2010); Muscio and Pozzali (2013); Siegel et al. (2004)
Institutional	Motivation	Transaction	Difficulty of finding partners at universities	Alunurm et al. (2020)
Operational	Capability	Orientation	Difficulty of contacting individuals in the industry	Muscio and Pozzali (2013)
Operational	Capability	Transaction	Lack of preparation of company personnel	Subramonian and Rasiah (2016)
Operational	Misalignment	Orientation	Insufficient face-to-face contact	Tootell et al. (2021)
Operational	Governance	Orientation	High levels of formality in conversations	Tootell et al. (2021)
Operational	Governance	Transaction	Quality of managerial leadership	Amaral et al. (2011)
Operational	Motivation	Orientation	Lack of autonomy to work with the industry	Chryssou (2020)

Table 6 Classification of facilitators of university-industry collaborations

Categories	References
Internal	
Organizational structure and technological capacity	Ribeiro and Nagano (2021); Santoro and Bierly (2006)
Development of course programs that include student internships and industrial visits	Chryssou (2020)
Organization of seminars and workshops for industrial employees	Chryssou (2020)
Efficient communication tools	Wallin et al. (2014)
Provision of background information about partners	Carvalho et al. (2015)
Dissemination of knowledge and the results of projects developed in partnership	Carvalho et al. (2015)
Setting up meeting places and creative working methods. Creation of dedicated university-industry interaction offices. Intensive interpersonal interactions and mutual learning as the project progresses	Chryssou (2020); Lee et al. (2010); Schulze-Krogh and Calignano (2020); Wallin et al. (2014)
Adoption of informal management styles that give partners autonomy over decisions	Canhoto et al. (2016)
Understanding the value of the project	Tootell et al. (2021)
Cognitive social capital	Steinmo and Rasmussen (2018)
Intellectual property and technology transfer policies	Santoro and Bierly (2006)
Internal technology-based relationships	Santoro and Bierly (2006)
External	
Construction of social relationships. Development of trust and social connections	Alunurm et al. (2020); Santoro and Bierly (2006); Steinmo and Rasmussen (2018); Tootell et al. (2021)
Building trust between partners through a strong leadership (relational dimension)	Ribeiro and Nagano (2021)
Assistance of intermediate organizations in knowledge/technology transfer processes. Stimulation of cooperation through the creation of technology parks and business incubators. Establishment of industry liaison offices (ILOs)	Lee (2011); Ribeiro and Nagano (2021); Tootell et al. (2021)
Geographic proximity between university and the company	Ribeiro and Nagano (2021)
Governmental incentives (programs, legislation and tax exemptions)	Ribeiro and Nagano (2021)
Invitations to industry speakers from the university	Chryssou (2020)
Involvement in university committees	Chryssou (2020)
Mechanisms to connect universities with industries	Chryssou (2020)
Promotion of joint projects through research funding agencies. Financial support from the governmental	Alunurm et al. (2020); Carvalho et al. (2015)
Encouragement and mediation of research and innovation by government bodies	Carvalho et al. (2015)

Table 6 (continued)

Categories	References
Provision of funding by external partners	Canhoto et al. (2016)
Combination of different types of knowledge and skills	Canhoto et al. (2016)
Development of mutual understanding	Tootell et al. (2021)
Understanding partner and community values	Tootell et al. (2021)
Trust built on past experience and reputation	Tootell et al. (2021)
Demonstration of a genuine interest in the success of the partner	Tootell et al. (2021)

and make a significant contribution to the economic development of society (He et al. 2021).

Cluster 1 highlights the importance of overcoming barriers relating to differential research time lines and the integration of work activities, knowledge development and the commercialization and/or intellectual property protection in order to establish successful long-term partnerships (Etzkowitz and Leydesdorff 2000). Cluster 2 emphasizes the importance of trust and personal relationships between universities and companies (Alexander et al. 2020). Cluster 3 highlights the issue of cultural differences between companies and universities as a barrier to collaboration and reinforces the importance of establishing long-term partnerships as in Cluster 1 (Valentín 2000). The need to establish a common language among the parties involved is emphasized in all clusters. For example, lack of effective communication between the parties is a common problem that can hinder the establishment of long-term partnerships, the overcoming of cultural differences, and the building of personal relationships and trust (Bruneel et al. 2010; Galán-Muros and Plewa 2016; Wit-de-Vries et al. 2019). This suggests that effective collaboration between universities and companies requires surmounting technical and cultural barriers together with the creation of a long-term relationship based on mutual trust and common goals.

The results of our study show that the various barriers and facilitators interact throughout the collaborative process (Fig. 5), but two barriers deserve particular consideration, namely cultural conflicts and issues related to intellectual property. Some tools that can be used to overcome these barriers require direct government action, such as the introduction of tax incentives (Simachev et al. 2014), promotion of cooperation through innovative development programs, and support for projects between companies and universities. Wit-de-Vries et al. (2019) emphasized the importance of experience in dealing with differences in expectations regarding the outcome of the project.

He et al. (2021) found that orientation asymmetry has a positive effect on cognitive and affective conflict between academic and industrial partners. These authors proposed the implementation of training and development programs to improve skills and competencies for dealing with conflicts and suggested solutions for cognitive and affective conflicts. The importance of cognitive and affective trust in UICs

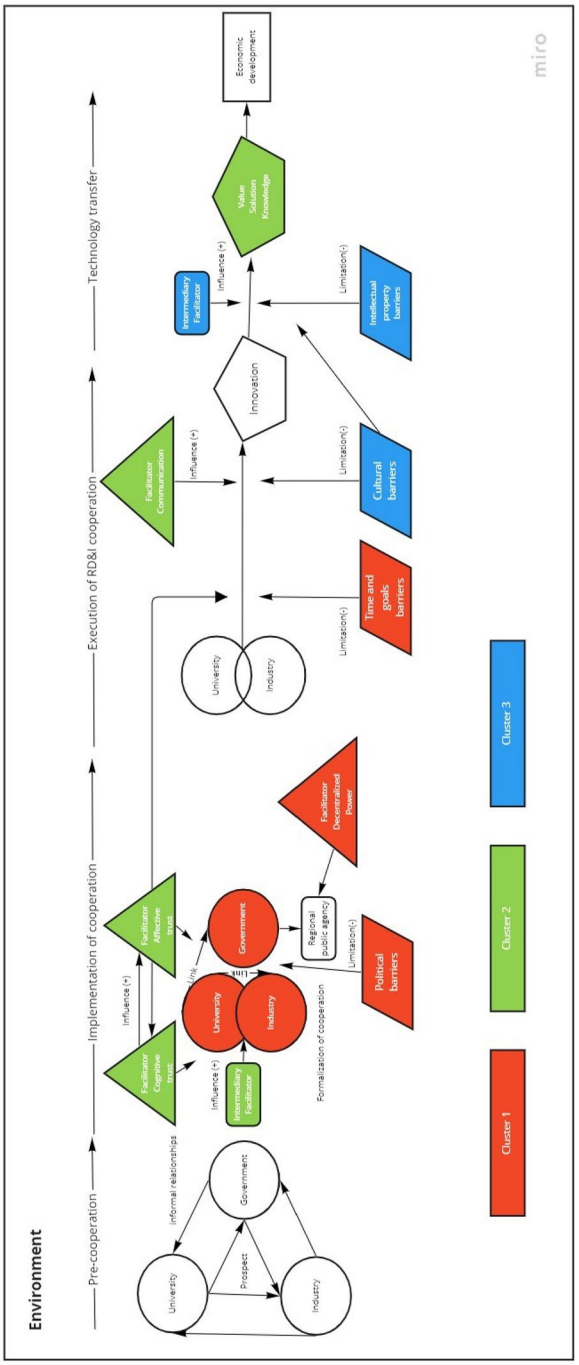

Fig. 5 Conceptual framework of the influence of barriers and facilitators on university-industry collaborations

is reinforced by other studies (Muscio and Pozzali 2013; Steinmo and Rasmussen 2018; Tootell et al. 2021) since the presence of both influences relationships positively.

Autio and Laamanen (1995) explained that technology transfer depends on the deliberate interaction between various participants in pursuit of a common goal, and such relations may occur formally or informally throughout the cooperation process. Assistance from well-qualified intermediaries has been recognized as one of the facilitators of the process of cooperation, particularly when such professionals have academic and industrial experience and are able to narrow the cognitive gap that facilitates technology transfer (Villani et al. 2017). Qualified intermediaries can facilitate effective collaboration between academic and industrial partners by identifying suitable contact personnel for initiating discussions and addressing funding constraints and other issues. Additionally, intermediaries can help establish communication between partners, mitigate conflicts, and ensure that the intellectual property of the industrial partner is protected.

Overcoming cultural differences and barriers requires effective communication, mutual understanding, and trust-building between partners, as well as the assistance of qualified intermediaries. The success of UICs depends on the deliberate interaction between various participants in pursuit of a common goal, including intermediaries, academic researchers, and industrial partners.

Many points addressed in this review have already been discussed in the literature with a view to enhancing the facilitators of cooperation. Indeed, several facilitators are, in effect, the reverse of barriers so that success happens by removing barriers. In practice, however, it is not so simple, and successful relationships require constant monitoring by the parties.

7 Conclusions, limitations and future research directions

This systematic review aimed to identify the barriers and facilitators of UICs and analyze them using bibliometric tools. The establishment of UICs for the purpose of RD&I remains a challenging process. Research into the triple helix model of collaboration has concentrated on the analysis of the interactions between academia, industry and government. However, few publications have focused on the role of the government in detail, and some authors (Brundin et al. 2008) have found it difficult to identify any government interaction in studied cases. Ribeiro and Nagano (2021) have suggested implementation of an in-depth investigation of the barriers and facilitators of interactions between the components of the triple helix in the Brazilian context, together with an examination of the factors that minimize the barriers or enhance the facilitators of this process. At the same time, comparisons should be drawn between approaches to organizational arrangements based on the triple helix model (Razak and White 2015).

The technological innovation generated from UICs must be accompanied by the creation of value, which, from the industrial viewpoint, is linked to financial return (Wirsich et al. 2016). However, the effects of UICs on commercial outcomes and financial performance are poorly understood and deeper analysis is required.

Steinmo and Rasmussen (2018) argue that the historical analysis of RD&I projects undertaken by UICs is limited and that it would be more advantageous to investigate the interplay of cognitive and relational social capital in partnerships in real time. In this way, the evolution of mechanisms of the collaborative process and the contributions of different dimensions of social capital to the success of relations could be ascertained during the course of the project.

Over the last few years, and prompted in no small part by the COVID-19 pandemic, online communications have become part of everyday life and virtual relationships are normal. Within this scenario, it would be important to analyze more carefully the pre-pandemic suggestion of Canhoto et al. (2016) regarding the importance of face-to-face *vs.* distant interactions. Another point to be considered is the opportunistic behavior that occurs when unfairness, imbalance of benefits or asymmetry of power is perceived in a partnership. While power asymmetry can be counterbalanced by activating management controls and redirecting ethical behavior (Tootell et al. 2021), it is necessary to explore whether such interventions to prevent opportunism might constrain collaborative efforts. Mannak et al. (2019) highlighted the need to investigate the issue of different research time frames in university (long-term) and industry (short-term), and suggested the creation of strategies for time management and guidelines for administering innovation networks.

Filippetti and Savona (2017) draw attention to territorial proximity (physical, organizational, social or other space) and the analysis of barriers across different scientific areas, since these represent challenges for UICs focused on innovation. Muscio and Pozzali (2013) have proposed that a more detailed investigation be carried out to explore how cognitive distance, defined as the degree of diversity in research methodologies and in the use or interpretation of knowledge, is perceived by companies, with special emphasis on whether the multidimensionality of the concept is adequately explained by the indicators presented in their study. Intellectual property has proven to be a challenging issue in collaborations and, for this reason, Bruneel et al. (2010) maintain that it is important to perform *ex-ante* studies (using structural models and simulations) to predict the impacts of intellectual property provision on the success of collaborations. These authors also mention the need to analyze how the progression from informal and infrequent collaborations to long-term collaboration occurs.

Finally, few articles have analyzed UICs according to a strategic theoretical framework, but instead have focused only on the factors that influence the relationships and their relative importance to the parties. Theoretical analysis can help in setting the limits of discussions to the most frequent problems encountered in the partnerships. In this context, our bibliometric analysis established that some of the selected papers consider strategy models, namely: resource-based theory ($n=3$; Alunurm et al. 2020; Galán-Muros and Plewa 2016; Wirsich et al. 2016); knowledge-based theory ($n=1$; Santoro and Bierly 2006); evolutionary economics ($n=2$; Rapini et al. 2017; Simachev et al. 2014); institutional theory ($n=2$; Brundin et al. 2008; Lind et al. 2013); and agency theory ($n=2$; Calvo et al. 2019; Siegel et al. 2003). Based on the findings of this systematic review, we conclude that future research should explore the points summarized in Table 7.

Table 7 Topics for future research on university-industry collaborations (UICs) for the purpose of research, development and innovation (RD&I)

Theoretical models	Topics and objectives
Triple helix and the entrepreneurial university	Analyze the role of government and its interactions in the triple helix model Detailed investigation of the barriers and facilitators of knowledge management and university-industry-government collaborations and the minimizing or enhancing factors Comparative studies of university-industry-government collaborations according to different arrangement models Comparative studies of the application of the triple helix model in developed and developing countries, in order to explain how successfully to implement this model by analyzing how barriers and facilitators occur in different places
Social capital and value creation	Study the effects of UICs on financial performance Understand the social capital mechanisms underlying real-time interorganizational collaborations and how the dynamics of these mechanisms occur over time Analyze the importance of face-to-face *vs.* distant relationships in RD&I co-production projects Determine whether organizational controls designed to reduce the risks of opportunism constrain the effectiveness of collaborative innovation efforts Examine the consequences at the network level of time-use strategies and provide guidance to policy makers for managing innovation networks
Technology transfer and cultural differences	Analyze the barriers to innovation that interfere with joint research in specific research fields Determine what kind of proximity (spatial, institutional, organizational) would play a decisive role for UICs in different domains of knowledge Investigate how cognitive distance is perceived by companies Perform *ex-ante* studies to predict the impacts of intellectual property provisions on the success of collaborations Investigate the progression from informal and infrequent collaborations to long-term collaboration

Similar to UICs, this research also had to overcome obstacles and suffered from some limitations. One of the main constraints was the choice of the Scopus database over all others. Since it would have been a herculean task to analyze all available databases, we opted for a single database with a wide scope. Another limitation is related to the heterogeneity of the theme and the selection of appropriate search terms. Future research in this area could use terms relating specifically to RD&I projects.

The present systematic review identified 86 articles dealing with barriers and facilitators of UICs for RD&I, and these were analyzed using bibliometric tools.

The 75 articles that were considered in depth could be classified into three clusters, each of which focused on the barriers and facilitators from a distinct perspective, namely the triple helix model and the entrepreneurial university, the relational social capital and social value creation, and technology transfer and cultural differences. We established that studies regarding to the barriers and facilitators of UICs have increased substantially in recent years, mainly between 2016 and 2021. There is a general consensus regarding the existence of cultural differences between the collaborating parties and the need for improving cognitive and affective trust. Other authors clarified the influence of systemic barriers, relating mainly to finance and knowledge, on the delivery of innovation by UICs. It is clear that fostering relational social capital is fundamental to the maintenance of collaborations, along with an appropriate combination of skills and competencies and the delivery of impactful results. It appears that the longer the life cycle of collaborative project, the greater are the benefits for both partners. The challenges to the successful implementation of UICs can be overcome by means of various tools, especially the provision of tax incentives to facilitate the pursuit of innovation by industries through partnerships with academia. Another interesting approach to overcoming collaborative barriers in RD&I is through experience, by starting with smaller projects and gradually increasing their complexity. This strategy not only generates benefits for both parties, but also prolongs partnership.

The present study contributes to the literature relating to UICs for RD&I by providing a comprehensive analysis of the barriers and facilitators from different perspectives and by offering insights on how to improve these collaborations. In addition, our findings broaden the theoretical understanding of UICs for RD&I and provide practical implications for universities, industries, and governments in promoting successful collaboration with innovation. The bibliometric analysis presented herein revealed an increase in studies relating to UICs in recent years and reinforces the relevance of this topic.

From a theoretical standpoint, this review sheds light on the importance of relational social capital, cognitive and affective trust and the need to overcome cultural differences and systemic barriers to achieve successful collaborations. Moreover, our findings suggest that the longer the life cycle of a collaborative project, the greater the benefits for both partners. From a practical viewpoint, this study offers insights for universities, industries, and governments on how to improve UICs for RD&I. Tax incentives could be provided to facilitate partnerships between industry and academia and to promote innovation. Experienced intermediaries with academic and industrial backgrounds could be engaged to facilitate the communication between the collaborating parties, especially in the initial stages of a project. Furthermore, the principles proposed by Canhoto et al. (2016) could be adopted to overcome the difference in the perception of goals between partners. Universities and industries should consider starting with smaller projects and gradually increasing their complexity, as proposed by Wit-de-Vries et al. (2019), in orde to gain experience and extend their partnerships.

Author contribution All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by ALR, EPGV and RLCR. The first draft of the manuscript was written by ALR and all authors commented on early versions of the manuscript. The critical review of the manuscript was carried out by EPGV and RLCR. All authors read and approved the final manuscript.

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Data availability The data that support the findings of this study are available from the corresponding author upon request.

Declarations

Conflict of interest The authors have no relevant financial or non-financial interests to disclose.

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