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Mapping the evolution of university-industry collaboration: A systematic literature review from 2000 to 2022

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ABSTRACT

This research aims to improve knowledge exchange and innovation through collaborations between universities and industries in South-East European Countries (SEECs). The region benefits from better collaboration, and understanding factors such as proximity, motivations, and challenges is crucial. The study begins by suggesting that geographical closeness may influence the strength of university-industry ties and that specific conditions in SEECs may either support or impede these relationships. The paper proposes a new University-Industry Collaboration (UIC) model tailored for SEECs, built upon a review of literature from 2000 to 2022. This review examines factors like location, organizational approaches, types of knowledge exchange, key motivators and barriers, and the evolving role of universities in the region. The study introduces a specialized UIC model that could enhance regional cooperation, emphasizing strategies to overcome barriers and align university and industry goals. By extensively reviewing existing research, the paper contributes valuable insights into UIC in SEECs, aiming to deepen the understanding of these collaborations in the region.

1. Introduction

The imperative for fostering robust relationships between universities, industries, and governments has become increasingly evident in the contemporary landscape (Bürger and Fiates, 2024). This alignment holds the promise of a prosperous economy, enhanced employability prospects, and a heightened level of innovation. The triple helix model (THM), introduced by Etzkowitz and Leydesdorff (1998) and used by many researchers (De Lima Figueiredo et al., 2023; James et al., 2023; Murillo-Luna et al., 2023) provides a foundational framework that underscores the significance of these collaborations. The THM posits that the creation of knowledge is contingent on the synergies cultivated between universities, industries, and governments, a dynamic often characterized as a 'highly charged intellectual enterprise' (Todeva and Etzkowitz, 2013).

Our research is centered on the vital nexus of collaboration between universities and industries (UI). This collaboration hinges on exchanging information, knowledge, and expertise, along with various collaborative elements such as joint publications, workshops, conferences, and staff recruitment (Ankrah and Omar, 2015). Universities primarily cultivate problem-solving talent, foster regional cultural support (Goddard and Chatterton, 1999), and assist industries in innovative pursuits (Chesbrough and Crowther, 2006). In contrast, industries are driven by profit generation, and their viability is intrinsically linked to the value they create and capture. Traditionally, universities and industries had distinct and independent roles, but the contemporary landscape necessitates active cooperation, where knowledge creation thrives on the synergies forged through their interaction (Todeva and Etzkowitz, 2013).

The benefits of university-industry collaboration (UIC) as a potent mechanism for economic growth are increasingly evident and actively pursued. The dynamic collaboration between these actors promises to foster innovation (Audretsch and Feldman, 2004). This evolving landscape also presents unique challenges due to differing objectives and constraints for universities and industries (Rybnicek and Königsgruber, 2019).

Despite the growing recognition of the importance of UIC, there is currently a lack of a proximity-based UIC framework that leverages Stakeholder Theory (ST), Complex and Adaptive

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Theory (CAST), and Institutional Theory (INT) to bolster regional growth while capitalizing on the unique strengths of the region. The proposed framework catalyzes innovation, increased employment, and economic growth in South-East European Countries (SEECs). Each conceptual framework is independent and interconnected in shaping the proposed UIC framework for SEECs.

This research undertakes a systematic literature review to identify critical conceptual frameworks integral to the proposed UIC framework, which is envisioned as an imperative for economic and societal prosperity. The central aim is to propose a UIC framework grounded in institutional interactions, drivers, barriers, organizational forms, types of interactions, and their scaling to macro-level and community-level contexts. This endeavor encompasses a comprehensive understanding of theories and conceptual frameworks that underpin the UIC landscape.

The research objectives are firmly anchored in this backdrop and encompass the following specific goals:

Objectives:

1. Examine the literature comprehensively through a systematic literature review to investigate the drivers and barriers of UIC across different tiers of geographical proximities.
2. Conduct an in-depth literature review to identify the most suitable organizational forms and types of interactions within the context of SEECs.
3. Comprehend stakeholder behavior and their complex roles in UIC within SEECs.
4. Understand the implications of conceptual frameworks originating from different stakeholder levels on UIC within SEECs.
5. Propose a framework of UIC for the case of SEECs.

This research sets the stage for a deeper exploration of UIC within the unique context of SEECs, emphasizing the multifaceted dynamics that influence knowledge exchange and innovation, laying the groundwork for a more prosperous and innovative future.

2. Background and importance

A well-designed UIC framework with dynamic components facilitates the demonstration of a willingness to collaborate among participants. Kaymaz and Eryiğit (2011) described UICs as having diverse missions and drivers, with universities typically engaging in collaborations to advance teaching, increase fundraising, enhance their reputation, and gain access to empirical data. Conversely, firms often seek collaboration with universities to access advanced technology and public funding, participate in training sessions offered by academic staff, connect with skilled workers, and share costs to mitigate risks. Additionally, Albats et al. (2016) have identified several barriers to UICs, although specific barriers are not detailed in this excerpt. These elements highlight the complex motivations and challenges involved in establishing effective university-industry partnerships:

- Collaboration is costly, and the returns accrue only in the medium and long term;
- Regarding output, firms are not interested in disclosing information, whereas universities are interested in publishing research results as soon as possible;
- Transaction costs of finding the right person are some of the difficulties in negotiating a collaboration;
- Misalignment of expectations with regard to IP rights and making a profit from them is an issue by which the industry is concerned.

UICs consist of formal and informal collaborations, where formal UICs are mainly organized under equity partnerships, contracts, research projects, and patents, whereas informal UICs mainly consist of intellectual property, mobility, publications, conferences, focus groups, and other possible ways of informal collaborative activities between UI (Hagedoorn et al., 2000). According to Guimón (2013), UIC can take the form of short-term collaborations, typically involving research contracts, or long-term collaborations, which have a greater potential for innovation and usually involve joint projects and public-private partnerships (Koschatzky and Stahlecker, 2010).

The systematic literature review covered relevant articles to answer the following research questions:

- What are the key drivers, benefits, and barriers for UIC in different tiers of geographical proximities;
- What are the relationships between geographical proximities and organizational forms and types of knowledge interaction between actors?
- What is the role of the conceptual frameworks in the proposed UIC framework?

Many studies highlight the positive impacts of UIC on regional economic development, job creation, and technology commercialization, which are key to fostering innovation and economic growth. UICs facilitate the transfer of knowledge from academia to industry, enhancing product development and problem-solving across various collaborative models such as joint research projects, incubators, and technology parks. However, much of the research does not sufficiently address the contextual factors that influence the success of UICs. Often, the literature tends to focus on short-term gains while neglecting the long-term benefits. Additionally, many studies face methodological challenges and struggle to accurately measure the true impact of these collaborations. Our proposed framework seeks to integrate different conceptual frameworks at various stakeholder levels, which can significantly influence the outcomes of university-industry partnerships.

This is why our framework aims to serve as standardized evaluation metrics to assess the success and impact of UICs effectively.

This study emphasizes the importance of understanding organizational forms, interaction types, and the drivers and barriers experienced at different levels of geographical proximity to develop an effective UIC framework. The research primarily focuses on conceptual frameworks that outline the optimal conditions for UIC. However, designing such a framework requires a deep understanding of these conceptual frameworks across various stakeholder levels, as well as recognizing the significance of UIC in contributing to innovation and economic development in SEECs.

The primary purpose of this study is to comprehensively explore the realm of UIC, encompassing the identification of organizational structures and models, an investigation into the drivers and barriers influencing these partnerships, an examination of the dynamics between academic institutions and industry players across various levels of geographic proximity, and a deep dive into the changing roles of entrepreneurial and engaged universities over time. The ultimate purpose is to craft a region-specific UIC framework that will effectively stimulate innovation and promote economic development within that particular geographical context.

The study presents a comprehensive UIC framework that greatly enhances collaboration in a specific region, delineating its operation across micro, meso, and macro levels. At the micro-level, individual conceptual frameworks bolster human resource development and knowledge transfer. The meso-level encourages institutional collaboration through informal interactions and commercialization efforts. Meanwhile, the macro-level underscores community-level frameworks and resource sharing. These findings align with Carayannis and Campbell's (2010) model, supporting knowledge diffusion, market-oriented innovation, intellectual and social capital, and policy support. The study's contributions span theory, practice, policy, and social realms, offering insights into theory integration, adaptable strategies, policy recommendations, and long-term regional growth and employment prospects, particularly in Southeast European Countries (SEECs).

2.1. Conceptual frameworks of the proposed UIC framework

Several proposed conceptual frameworks have emerged that illustrate effective collaboration methods between universities and industries, utilizing various types and organizational forms of interaction between these key stakeholders. The suggested UIC framework is structured around three different levels of stakeholders, incorporating multiple conceptual frameworks to optimize these partnerships. Open innovation is an open process of innovation (Chesbrough and Crowther, 2006), where internal and external innovative ideas involve interaction between actors (Caniëls and Van den Bosch, 2011). Open innovation is an important mechanism for firms that intend to improve current business performance, as well as for firms that intend to achieve longer-term growth, usually involving other significant stakeholders, such as universities (Chesbrough and Crowther, 2006). Regional innovation system (RIS) explains how innovation systems operate at international and national levels (Gunasekara, 2006); therefore, engaged universities focus on the need to exchange knowledge between regional actors (Gunasekara, 2006). Engaged Universities significantly facilitate the UIC in a specific region. The model that can drive the transition of a specific region is the Triple helix model, which consists of hybrid roles of university, industry, and government**.** To achieve this hybrid attitude, universities should transform themselves into entrepreneurial universities, be open to the industry, collaborate systematically, and promote innovation in linear terms that make possible the flow of inventions that, in turn, would be commercialized (Etzkowitz, 2003). This hybrid role facilitates opportunities for cross-employment, internships, and joint research projects. Cross-employment refers to a worker who is simultaneously employed by more than one organization (Campbell, 2013), whereas Internships and apprenticeships are temporary movements of students from HEIs to business for different research projects and other purposes. (e.g., student's experiences).

The Triple helix model is a model developed by Etzkowitz and Leydesdorff (1998). It is part of our framework, and it refers to the extensive and active cooperation between Business – Academia – Government. It argues that the creation of the knowledge base depends on the synergies created by the interaction of the three main mentioned actors, which is described as a 'highly charged intellectual enterprise' (Todeva and Etzkowitz, 2013). Instead of focusing simply on bilateral public-private interactions where the university is a producer of knowledge, which is then transferred to the private sector via the publication of articles and the provision of education people, THM encompasses trilateral relationships between the industry, government, and universities (Etzkowitz, 2002). Etzkowitz (2002) identified three main configurations for University-Industry-Government interactions. The first configuration, referred to as "bottom-up" initiatives, is viewed as a less successful model where innovation tends to be discouraged. The second configuration aims to diminish the government's role compared to the first, focusing more on direct interactions between universities and industries. The third configuration introduces hybrid roles for universities, industries, and government, facilitating a more integrated approach to innovation and development (Etzkowitz and Leydesdorff, 2000).

Fig. 1 illustrates three theoretical models related to UIC.

In the context of UIC, three theoretical models are outlined:

- TH1. Etatistic model of UIC: This model represents a structured approach where stakeholders, such as universities, industries, and government, operate independently without much collaboration between them.
- TH2. Laissez-faire policy of UIC: This policy suggests minimal government interference or regulation, allowing the collaboration between universities and industries to develop more organically and spontaneously.
- TH3. Triple helix model of UIC: This model emphasizes the interconnected and collaborative roles of universities, industries, and government. It supports the idea that through combined efforts, these entities can significantly foster innovation and economic development.

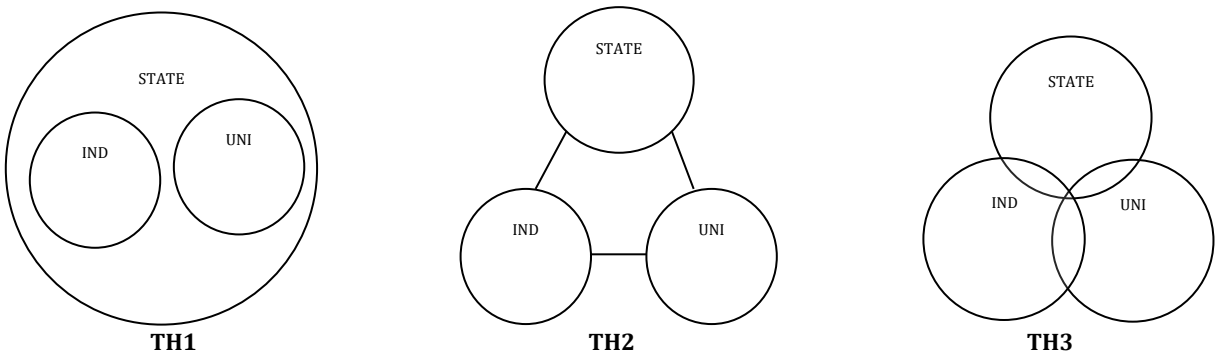

Fig. 1: TH1: Etatistic model of UIC; TH2: Laissez-faire policy of UIC; TH3: Triple helix model of UIC (Etzkowitz and Leydesdorff, 2000)

Inventions are considered to be generated by the "knowledge infrastructure" (universities), developed by the "support structure" (incubators), and commercialized by the "production structure" (business) (Etzkowitz and Leydesdorff, 2000). However, the following Fig. 2 presents Leydesdorff's (2003) approach, which is known as Triple Helix Dynamics, where innovation through actor interactions emerges from different types of communication.

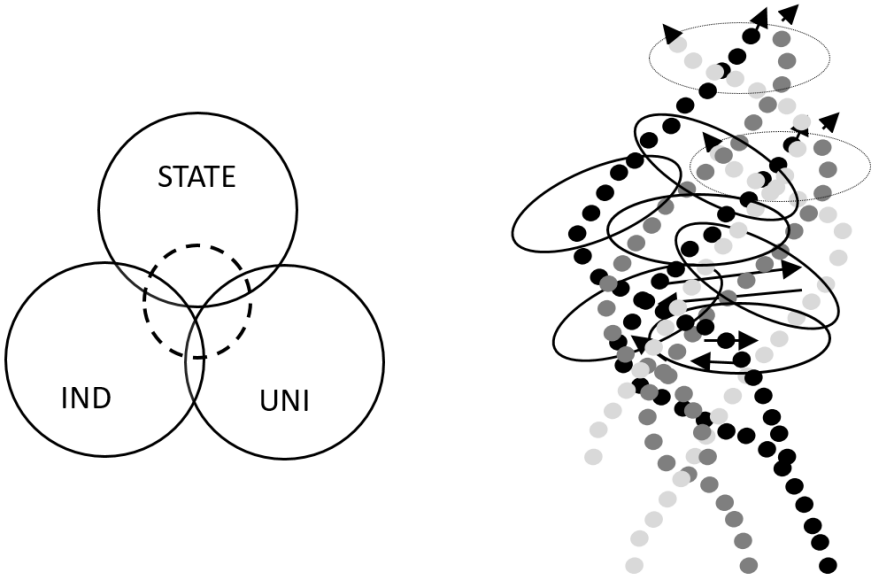

Fig. 2: Triple helix dynamics (Leydesdorff, 2003)

According to Table 1, a Triple Helix partnership can be thought to develop through three phases, each creating a keyspace. The initial phase consists of creating the knowledge space that will provide the building blocks for regional growth. A consensus space is created in the second phase, during which different actors in the region can meet and discuss local challenges on a neutral ground. In the third and final phase, the partners jointly form an innovation phase, where innovation occurs when the three partners take on parts of each other's roles while continuing to exercise their main objective (Etzkowitz, 2008).

Table 1: Triple helix spaces (Etzkowitz, 2008)

Triple helix spaces	Characteristics
Phase space 1: Knowledge	Actor's collaboration for innovation, focusing on R&D activities
Phase space 2: Consensus	Ideas are generated in a reciprocal among institutional sectors
Phase space 3: Innovation	The central role is attracting public and private venture capital

Based on Fig. 3, Etzkowitz (2013) explained the linkages of knowledge, innovation governance, and leadership through knowledge space as a source of the resources to commercialize; consensus space that brings the triple helix actors together to analyze what is needed to be done and to translate knowledge into economic use; and the innovation space which tends to train people on how to work together as an organization or entity.

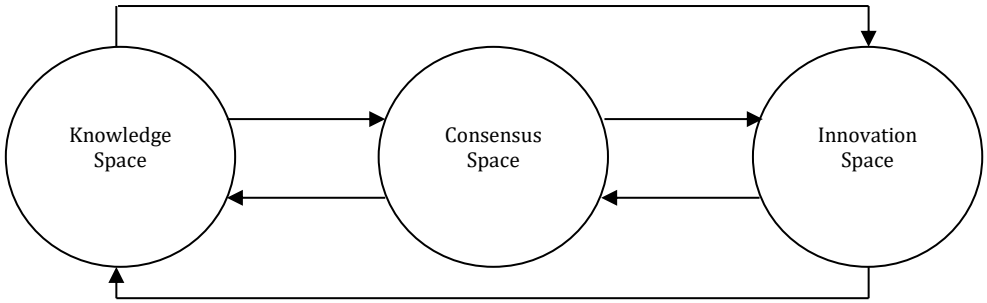

Fig. 3: Linking knowledge, innovation governance, and leadership (Etzkowitz, 2013)

2.2. Drivers, benefits, and barriers of university-industry co-creation

Several factors motivate effective UIC, with distinct drivers for each sector. Governments have been systematically promoting UICs to boost innovation efficiency and wealth creation (Barnes et al., 2002). In response, universities are increasingly aligning their efforts with government policies to enhance these collaborations (Perkmann et al., 2013). Universities contribute their extensive research capabilities, while industry brings expertise in product development and commercialization. Such collaborations not only foster innovation but also expand employment opportunities for university graduates ((Lee and Win, 2004; Santoro and Betts, 2002). Carayol (2003) notes that industry funding typically involves fewer bureaucratic hurdles than public funding, allowing universities to lessen their reliance on public funds and enabling faculty members to achieve financial gains more readily (Siegel et al., 2003).

An important motivation for universities to engage in collaboration with industry is the opportunity to publish in academic journals, which aligns with their fundamental mission of disseminating knowledge (Harman and Sherwell, 2002; Newberg and Dunn, 2001). Industries also see significant benefits in collaborating with universities, often aiming to leverage governmental programs that support such partnerships. Industries engage with universities to access student talent through summer internships and hiring both students and experienced researchers (Ankrah, 2013; D'Este and Perkmann, 2011; Siegel et al., 2003). Additionally, industries may gain financial and innovative advantages from the unexpected outcomes of research activities and other innovative outputs (George et al., 2002). These factors are crucial drivers for firms seeking partnerships with academic institutions.

It's crucial to understand that universities can have varying orientations toward regional and international collaboration. According to Rohrbeck et al. (2006), as illustrated in Table 2, universities with a strong regional focus might prioritize local skills and businesses in their collaborative activities. Importantly, the presence of incentives for collaboration does not always correlate with the actual level of interaction between actors; this level of interaction is greatly influenced by the available communication opportunities. Therefore, even if there are substantial incentives to engage on an international scale, the practical capacities for communication might lead actors to adopt a regional focus in their interactions (Rohrbeck et al., 2006).

Boccanfuso (2014) recommended several principles for UIC in regional and international orientation:

- Successful UIC should support the mission of each partner;
- Institutional policies should focus on fostering appropriate long-term partnerships between actors;
- Universities and Industries should focus on the benefits of each actor to ensure the timely conduct of the research and the development of the research findings.

Rohrbeck et al. (2006) identified a summary of the motives for interaction between university and industry. Table 3 succinctly outlines the key benefits that both universities and industries can derive from collaboration, covering areas such as education, financial support, knowledge exchange, research, project stability, and talent acquisition.

Lambert (2003) considered the companies and the universities as two different entities, which are natural partners, even though their cultural and mission differences are significant and sometimes tend to constrain their interaction. Even though their constraints vary by discipline, the most significant constraints considered by the scientists are the lack of time, bureaucracy, and insufficient reward. However, D'Este and Perkmann (2011) identified potential mechanisms to reduce the UIC obstacles through the experience of collaboration, breadth of interaction, and inter-organizational trust. According to Hagedoorn and Schakenraad (1994), the

experience of collaboration is a critical determinant of the success or failure of inter-organizational alliances. Involvement in a variety of collaborations may contribute to better equipping the firm to manager conflicts (D'Este and Perkmann, 2011), whereas a high level of trust helps to reduce opportunism, resolve problems altogether, and align their behavior with the needs and expectations of partners (Zaheer et al., 1998).

Table 2: Drivers for universities and industry in regional, international, and mutual orientation (Rohrbeck et al., 2006)

	Regional orientation	International orientation
University	-Responsiveness to Government policy -Recognition within the scientific community-publications, grants (especially if untenured) - Strategic institutional policy -Access complementary expertise, state-of-the-art equipment and Facilities - A shift in the knowledge-based economy - Societal pressure - Service to the industrial community/society - Contribute to the regional or national economy	-Employment opportunities for university graduates - Business opportunity, e.g., exploitation of research capabilities and results or deployment of IPR to obtain patents -Protect and market the university's intellectual property -Access funding for research -Personal financial gain for academics - Discover new Knowledge - Obtain better insights into curricula development - Expose students and faculty to practical problems/applied Technologies -Publication of papers Promote innovation (through technology exchange) -Academics' quest for recognition or achieve eminence - Access to students for summer internship or hiring - The hiring of faculty members -Commercialize university-based technologies for financial gain - Benefit financially from serendipitous research results
Industry	- Responsiveness to government initiatives/policy -Strategic institutional policy - National incentives for developing such relations such as tax exemptions and grants - The shift in the knowledge-based economy - Business growth	- Cost Savings (easier and cheaper than to obtain a license to exploit foreign technology) Enhance the technological capacity and economic competitiveness of firms - Shortening product life cycle - Human capital development - Access new knowledge, cutting-edge technology, state-of-the-art expertise/research/facilities, and complementary know-how - Solutions to specific problems - Risk reduction or sharing - Enhancement of corporate image

Table 3: Driver for UIC (Rohrbeck et al., 2006)

University	Industry
Enhancement of teaching	Sourcing the latest technological advances
Funding/financial resources	Laboratory usage
Source of knowledge and empirical data	Personnel resources/cost savings
Political pressure	Risk sharing for basic research
Enhancement of reputation	Stabilizing long-term research projects
Job offers for graduates	Recruiting channel

2.3. Organizational forms and types of interaction between university and industry in different tiers of geographical proximities

The geographic proximity between universities and companies plays a significant role in facilitating knowledge exchange, especially when knowledge is socially accessible and only through physical interaction (Laursen et al., 2008). The study confirms the argument of Laursen et al. (2008) that a firm's propensity to collaborate with local universities in the innovation processes is winding at SEECs. The relationship between university and industry depends significantly on the characteristics of firms and universities and the related choices made by managers in firms and academics in universities (Laursen et al., 2008).

According to Barringer and Harrison (2000), the most famous organizational forms discussed in the literature are Joint ventures, Networks, Consortia, and alliances, which vary depending on the degree to which entities are linked. Different researchers present different typologies of UIC. For instance, Chen et al. (2019) classified the organizational forms of UIC for technology exchange based on the duration of the relationship and technology flow. On the other hand, Santoro and Gopalakrishnan (2000) classified UIC as research support, cooperative research, knowledge transfer, and technology transfer. However, another proposed framework on UIC by Bonaccorsi and Piccaluga (1994) consisted of six main categories, such as personal information relationship, personal relationships, third party, formal targeted agreements, formal non-targeted agreements, and the creation of focused structures. This proposed framework has been extended by the same authors to reflect additional information through three general dimensions: Organizational resources involvement from the university, length of the agreement, and degree of formalization.

According to Bonaccorsi and Piccaluga (1994), if the firm contacts the university representatives without any signed formal agreement, there are no involved organizational resources, whereas, in the case of formal personal relationships between actors, the agreement tends to be short-term and long-term in the case of focused structures. The formalization is a very significant factor because of the argument that increasing formalization and monitoring of the relationship in a UIC could lead to conflict among the parties in their attempt to maintain the autonomy of their organizations (Santoro and Gopalakrishnan, 2000). The organizational form in UIC is influenced by factors

beyond formalization, notably the geographical proximity of the actors. As noted by Ankrah and Omar (2015), the relationship between proximity to universities and firms' inclination to collaborate in innovation is intricate, dependent on the characteristics of both entities and choices made by managers and academics. The literature indicates that when universities and industries are distant, Networks become the predominant organizational form, emphasizing interconnected relationships. Conversely, in close proximity, Joint Ventures take precedence, highlighting the importance of nearness. Fig. 4 underscores the nuanced interplay of formalization, geographical proximity, and organizational forms in shaping collaboration dynamics between universities and industries.

The term knowledge interaction is used to describe all the following types of interactions between organizations and individuals from both sides. Firm size and government are considered very significant drivers for R&D cooperation with universities (Veugelers and Cassiman, 2005). According to Schartinger et al. (2002), collaborative research (joint research projects) between universities and firms involves formal agreements and requires personal (face-to-face) contact. Schartinger et al. (2002) suggested that when people read publications and patents, they usually don't need formal agreements or meet face-to-face with others from different institutions. However, face-to-face interaction is often necessary for individuals to explain knowledge that comes from their research.

To exchange knowledge, direct face-to-face contact is required to help individuals explain to one another knowledge emerging from research activities that are still fluid and only partially formed (Storper and Venables, 2004). However, firms must find ways to establish common interests and aligned incentives with their academic partners, and this can only be done by "being there" in order to establish a common background and share a set of expectations and understandings about the nature of the collaboration (Ankrah and Omar, 2015). Based on Table 4, the term knowledge interaction is used to describe all the following types of interactions between organizations and individuals from both sides.

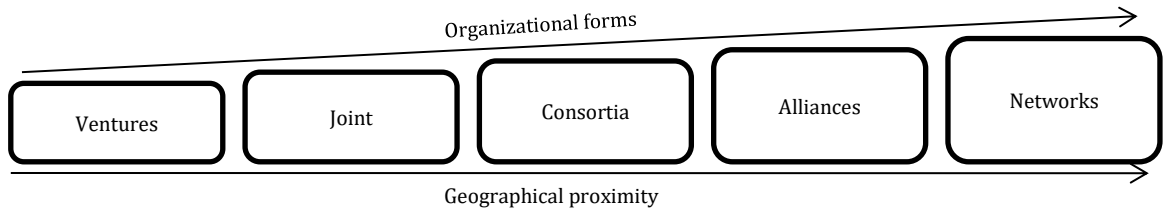

Fig. 4: Geographical proximity and organizational forms (Ankrah and Omar, 2015)

Table 4: Types of knowledge interactions between university and business (Schartinger et al., 2002)

Types of knowledge interaction	Formalization of interaction	Transfer of tacit knowledge	Personal (face-to-face) contact
Employment of graduates by firms	+/-	+	-
Conferences or other events with firm and university participation	-	+/-	+
New firm formation by university members	+	+	+/-
Joint Publications	-	+	+
Informal meetings, talks, communications	-	+	+
Joint supervision of PhD and master's theses	+/-	+/-	+/-
Training of firm members	+/-	+/-	+
Mobility of researchers between universities and firms	+	+	+
Sabbatical periods for university members	+	+	+
Collaborative research, joint research programs	+	+	+
Lectures at universities held by firm members	+	+/-	+
Contract research and consulting	+	+/-	+
Use of university facilities by firms	+	-	-
Licensing of university patents by firms	+	-	-
Purchase of prototypes developed at universities	+	-	-
Reading of publications, patents, etc.	-	-	-

+: interaction typically involves formal agreements, transfer of tacit knowledge; +/-: varying degree of formal agreements, transfer tacit knowledge, personal contacts; -: interaction typically involves no formal agreements, no transfer of tacit knowledge, no personal contacts

Finally, according to Laursen et al. (2008), there is a positive relationship between geographical proximity and the likelihood that they will collaborate.

3. Theoretical foundations of UIC

Theories are of critical importance to understanding the behavior of actors/participants within a social system (Morris et al. 2012). The core idea is how actors get organized with each other in a complex system that poses individual, institutional, and community pressures towards engaging in co-creation and innovation/knowledge exchange with the actors from the complex system (Rogers Everett, 1995).

3.1. Stakeholder theory (ST)

ST is being used by Freeman (1999) to measure stakeholder satisfaction and has progressed from management science into a theory offering the potential for use in analyzing the flow of knowledge between university and industry. Groups or

individuals who affect or are affected by actor objectives are defined as stakeholders (Freeman, 1999). In a complex situation where stakeholders interact to create outcomes, their needs and requirements become much higher (Goddard and Chatterton, 1999). However, stakeholder theory helped to develop the framework to reduce complexity in a complex situation by developing a framework that prioritizes stakeholder interests (Goddard and Chetterton, 1999).

An operational framework is a very important tool in such a complex system for orienting interactive activities between actors by considering conceptual frameworks from three different stakeholder levels (Davey, 2015). Three levels of UIC beneficiaries who gain from knowledge circulation in UIC are defined on a micro, meso, and macro scale. The micro-level includes individual stakeholders and corresponds to the individual conceptual frameworks such as cross-employment, internship, and research capabilities. The meso-level includes institutional stakeholders such as universities, businesses, and government and corresponds to the institutional conceptual frameworks such as triple helix, entrepreneurial university, and engaged university. The macro level includes community stakeholders and brings together society, region, science, and industry through a conceptual framework such as a regional innovation system and open innovation. According to Table 5, an operational framework is a very important tool in such a complex system for orienting interactive activities between actors by considering conceptual frameworks from three different stakeholder levels.

Table 5: Stakeholder levels and conceptual frameworks (Davey, 2015)

Level	Actor	Stakeholders	Conceptual framework
Micro	Individuals	Students, academics, and business staff	Cross-employment, research projects, and internships
Meso	Institutions	Universities, government, and businesses	Triple helix, entrepreneurial universities
Macro	Communities	Society, region, science, and industry	Region innovation system, open innovation, engaged university

3.2. Institutional theory (INT)

INT means social processes and all actualities that take status in social action through governance structure, rules and norms, social arrangements, and the way of organizing themselves and their interactions with other institutions. Because the UIC is the critical social science theory that drives the research, the contribution of this study to the theory and literature is on utilizing institutional theory to highlight the benefits and development possibilities derived by actors' interactions.

3.3. Complex and adaptive systems theory (CAST)

CAST explains synergy and how entities combine various knowledge of complex systems through interaction to achieve equilibrium and adapt it to the actors (Dooley, 1997). Universities are considered to have complex bureaucracies, whereas industry is by a simple profit motive. So, the role of CAST is considered a dynamic system that aims to adapt and evolve the actors' activities among each other, and this is exactly what the UIC should aim for. UIC is the critical social science theory that drives the research. Hence, explaining UIC from the perspective of conceptual frameworks is a new and very complex framework. However, a significant contribution of this study is to transfer the interaction's complexity into a simple and adaptive framework on UIC.

4. Methodology

A systematic review of the literature was conducted to answer the research questions. The study followed the principles of Tranfield et al. (2003), who emphasized core principles that apply to systematic reviews of literature in management and innovation. The systematic review of UIC comprehensively investigates the dynamics of UIC with a specific focus on the influencing factors across various geographical proximities. This research is motivated by the need to address existing gaps in the literature and gain a nuanced understanding of the drivers, benefits, and barriers associated with UIC in different contexts.

The primary objectives of this systematic review are threefold. First, the review seeks to identify and analyze the key drivers, benefits, and barriers for UIC in different tiers of geographical proximities. Second, it aims to examine the relationships between geographical proximities, organizational forms, and types of knowledge interaction between actors involved in UIC. Lastly, the review will investigate the role of conceptual frameworks in shaping the proposed UIC framework.

To achieve these objectives, the following research questions will guide the systematic review:

- What are the key drivers, benefits, and barriers for UIC in different tiers of geographical proximities?
- What are the relationships between geographical proximities, organizational forms, and types of knowledge interaction between actors?
- What is the role of conceptual frameworks in the proposed UIC framework?

To exclude some of the studies, Farrington's (2003) methodological quality scale assesses the methodological quality of evaluation studies through five criteria: internal validity, descriptive validity, statistical conclusion validity, constructs validity, and external validity. Articles and research reports included in academic journals from 2000 to 2022 indicate the potential of some relevant studies to be excluded from the review. This is an acceptable practice in the systematic literature review (Pittaway and Cope, 2007) because each research field appears continuously in subsequent journal papers. Even though the review covers the articles

from 2000 and 2022, there are fewer citations from 2017 to 2022, as the same theories, relevant models, and definitions appear in the previous year's articles. The second limitation concerns the keywords applied to control the inclusion criteria of the papers, where a careful approach was followed in the inspection process, which incorporates three steps: title, abstract, and full text.

Initially, the first two levels of keywords were employed in the title, abstract, and keywords search of Google Scholar, Scopus, and EBSCO Business Premier, which include 14,914 peer-reviewed journals. The search result returned 2470 articles until the end of 2021. The initial search result was further reduced gradually by using third-level keywords followed by excluding quadruple and quintuple papers and considering only journal articles in the English language. So, the total number of papers is 295. Afterward, the final shortlisting of papers was carried out by considering individual papers, given the context of the study, which provided the final 106 papers to be analyzed. Furthermore, the inductive approach has been used for data analysis. The analysis is performed in the following sections: initial data statistics, bibliometric analysis, and text visualization. BibExcel is used for bibliometric analysis. This includes author, affiliation, and keyword statistics. VOSviewer is used for the network analysis of the title and abstract text of shortlisted papers. The Google Scholar and Scopus databases classify the shortlisted papers into a number of subject areas. Most studies focused on university-industry interactions have recently been oriented toward Rees's detailed analysis of science–industry links in 1991. Since 1991, university-industry interaction has gradually become an important mechanism for innovation. Choosing only journal articles in English exclusively poses a potential source of language bias in the study. While this choice may have been influenced by practical considerations or the prevalence of English in academic literature, it is crucial to recognize the inherent limitation this imposes. By restricting the analysis to English-language publications, there is a risk of overlooking valuable research and perspectives in other languages. This limitation might introduce a bias that could affect the study's inclusivity and the representativeness of its findings. The possibility of missing diverse insights and to transparently discuss the potential impact on the study's overall scope and applicability may slightly affect the results.

5. Research results

Fig. 5 presents a comprehensive overview of the systematic review process, providing key insights and selection criteria for full paper analysis. An analysis of publication trends indicates a progressive increase in UIC publications. However, a noteworthy observation is the literature's limited representation of transitional economies. This suggests a potential research gap in understanding UIC dynamics in these regions. The step-by-step exclusion criteria and the resulting number of papers are given in Table 6.

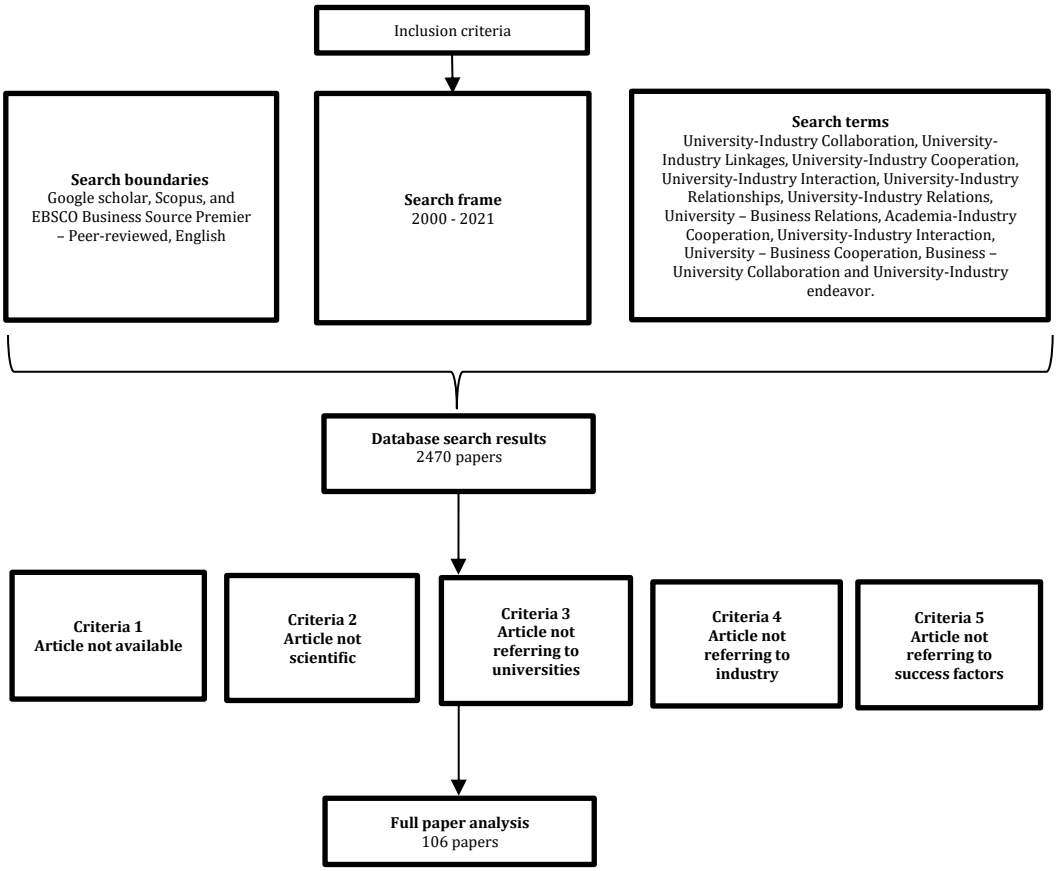

Fig. 5: Overview of the systematic review process

Table 6 accompanying Fig. 5 outlines the significant keywords of the study and the respective authors, along with the number of citations they have received. Table 6 shows the key and the most cited authors by the most significant keywords of the study, whereas Fig. 6 shows the frequency of the most cited authors per country.

Table 6: Keywords and key authors related to UIC

Keyword	Author and No. of citations
Triple helix model	Henry Etzkowitz, USA (31294), Loet Leydesdorff, Netherland (38283), Martin Meyer, UK (6077), Marina Ranga, Spain (1242), Emanuela Todeva, and UK (1109)
UIC	Donald Siegel, USA (31222), Ammon Salter, UK (15089), Markus Perkmann, UK (5009), Pablo D'Este, Spain (4450), YS Lee, and USA (2179)
Drivers and barriers of UIC	Ammon Salter, UK, and Pablo D'Este, Spain (616), Rene Rohrbeck, Denmark and HM Arnold, Germany (57),
Organizational forms and types of UIC	Omar AL-Tabbaa, UK (323) and Samuel Ankrah, UK (45), Jeffrey Harrison, USA (1456), Kathryn Walsh, and UK (877)
Entrepreneurial university	Allan Gibb, UK (809), Henry Etzkowitz, USA (5647), Paul Hannon, UK (1183), Burton Clark, UK (5469), Van Looy, Belgium (421), Chunyan Zhou, and China (141)
Open innovation	Henry Chesbrough, USA (27705), Kardon Crowther, USA (2068), Mark Dodgson, Australia (1689), Van den Bosch, Netherland (536), David Smith, and UK (79)
Regional innovation system	Philip Cooke, UK (3672), Chris Freeman, UK (2680), Bengt-Ake Ludvall, Denmark (1560), Loet Leydesdorff, Netherland (560), Henry Etzkowitz, and USA (168)
Systematic literature review	Richard Thorpe, UK (1150), David Tranfield, UK (968), Luke Pittaway, USA (596), Barabara Ann Kitchenham, UK (27), David Budgen, and UK (52)

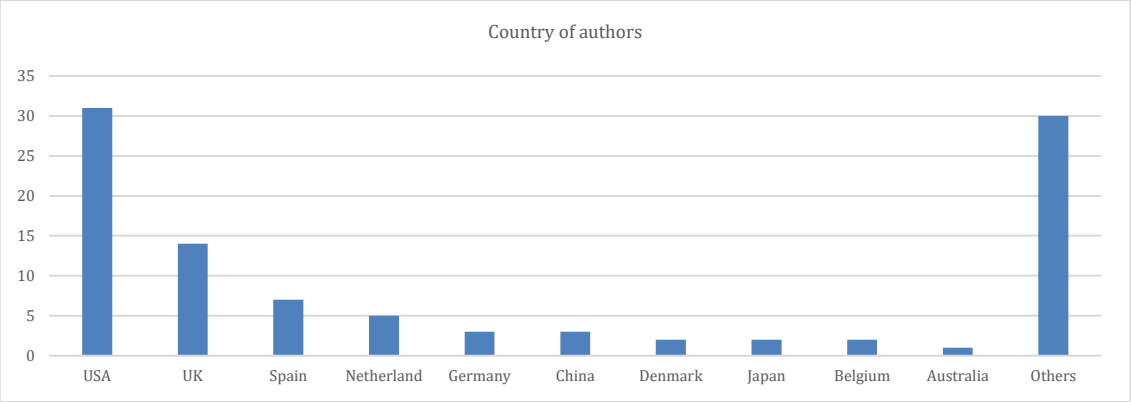

Fig. 6: Country of authors

Additionally, the chart illustrates the most targeted journals in the UIC field, providing insights into the focal points of scholarly activity and the distribution of papers across these journals. In summary, the systematic review uncovers key contributors and trends in UIC literature, emphasizing the need for increased attention to transitional economies and identifying journals central to the field. This summary provides a comprehensive snapshot of the systematic review findings and directs attention to areas for potential future research. The number of publications on UIC is progressive, but there are still not sufficient publications on transitional economies. However, Fig. 7 shows the most targeted journals and the specific number of papers published in these journals.

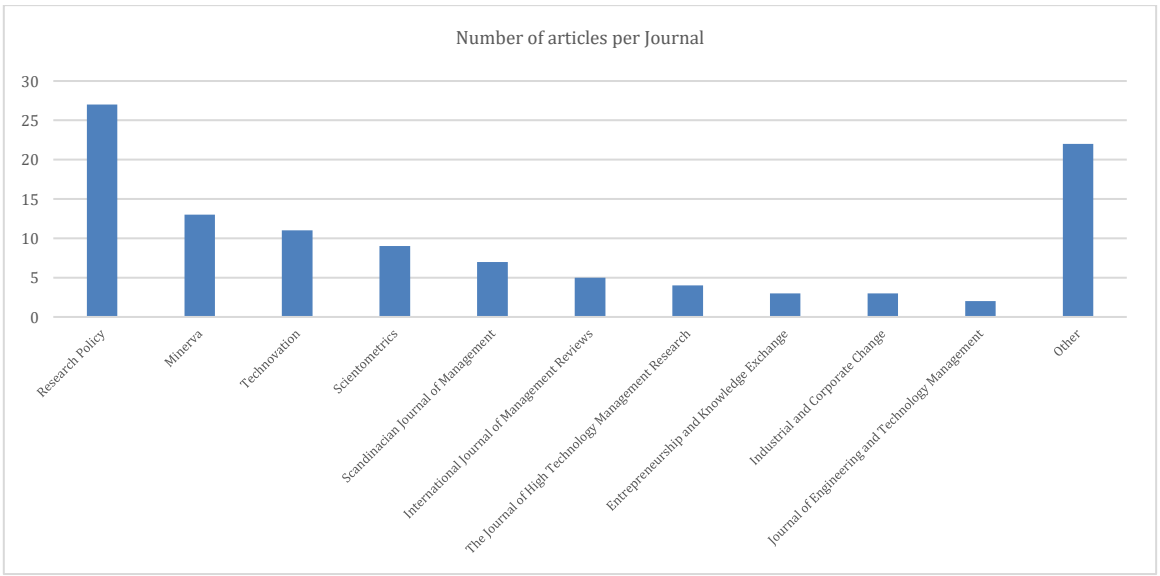

Fig. 7: Number of articles per journal

5.1. Key findings

The study proposes a UIC framework (Table 7) that significantly facilitates UIC activities in a specific region. It also defines the proposed UIC framework into micro, meso, and macro scales. Micro-level consists of individual conceptual frameworks such as cross-employment, internship, and research capabilities. The micro-level of the UIC framework focuses on individual conceptual frameworks and activities and specific interactions and collaborations at the individual level. It comprises three key conceptual frameworks: cross-employment, internships, and research capabilities. Therefore, human resources are trained and transferred from one institution to another, scientific knowledge is used within the industry, and university-generated intellectual property (IP) is transferred to the industry. Cross-employment involves individuals working in both academic and industrial settings, internships provide hands-on industry experience to students, and research capabilities focus on developing skills and knowledge transfer.

The Meso-level includes institutional conceptual frameworks such as the triple helix and the entrepreneurial university. At the meso-level of UIC, the institutions undertake informal interactions through forming social relationships, and institutions are oriented on development and commercial exploitation. The triple helix model emphasizes collaboration between academia, industry, and government. The entrepreneurial university promotes innovation and research commercialization within the academic institution.

The macro-level includes community conceptual framework such as regional innovation system, open innovation, and engaged university. At the macro level of UIC, universities share their infrastructure with the industry using activities launched by universities, such as labs, incubators, and university tech parks. The macro-level of UIC is characterized by research partnerships through the inter-organizational arrangements of actors. Regional innovation systems promote collaboration among various entities within a geographical region. Open innovation involves sharing and collaboration on ideas and research beyond organizational boundaries. Engaged universities actively participate in community development and industry collaboration.

The UIC framework's micro, meso, and macro levels generally offer a layered approach, addressing collaborations at the individual, institutional, and community scales, respectively. This hierarchical structure allows for a comprehensive understanding of UIC's diverse and interconnected nature.

Table 7: Conceptual frameworks in different levels and components

Levels	Conceptual framework	Components	Description
Micro	CE, INT, RP	HR training and transfers	Training, internships, staff secondments
		Scientific publications	Use scientific knowledge within the industry
		Commercialization of IP	Transfer of university-generated IP to firms
Meso	THM, EnU	Informal interaction	Formation of social relationships
		Academic entrepreneurship	Development and commercialization exploitation
Macro	RIS, EgU, OI	Shared infrastructure	Use labs, incubators, and university tech parks
		Research services	Research activities launched by universities
		Research partnerships	Inter-organizational arrangements by U-I

According to Carayannis and Campbell (2010), a proper UIC framework ecosystem can provide co-creation activities in the following means:

- Diffusion of research, knowledge, and innovation by building up human capacity not only through academic institutions;
- Utilization of the human capital, knowledge, and innovation for market purposes;
- The academic environment provides an ecosystem with intellectual capital;
- The social capital influences knowledge and innovation through cultural specificities and information movement;
- The political system influences and is influenced in order to enable sustainable co-creation among them.

Thus, the study's contribution can be categorized into four areas:

1. Theory: Progress in potentially combining three different theories more closely.
2. Practice: Implementation of significant strategies from the UIC framework tailored for the SEECs and utilized by the relevant institutions.
3. Policy: Suggestions for enhancing UICs in SEECs by addressing regulatory obstacles and inconsistencies in policies in this domain.
4. Social: Anticipation of long-term economic growth, development, and job opportunities in the SEECs.

6. Discussion

The discussion on UIC has generally agreed that dynamic and mixed interactions between various parties lead to better performance and more innovation. Despite this agreement, there are still significant areas that need further exploration to guide future research and development.

One major issue is the lack of clear definitions and studies on effective UIC frameworks. Experts highlight the need for well-defined, region-specific frameworks and call for more empirical research to explore how different parties coexist within these frameworks. This involves creating, testing, and improving UIC models that are tailored to specific

areas, which would help outline better ways for collaboration.

Another issue is that many discussions on UIC's role in economic and social progress lack a strong theoretical base. Some UIC models use complex theories from innovation, institutions, and stakeholders, but there is a need for stronger theoretical foundations to make these models clearer and more valid. This would help everyone understand the importance of UIC better.

Moreover, there is a growing need for empirical studies that look at how universities and industries can work together effectively, especially given today's dynamic conditions. Such research will uncover practical methods to enhance collaboration and integrate operations, keeping up with global changes. Global competition has made it crucial for institutions to develop hybrid relationships, and understanding these new dynamics is essential.

The most pressing research gap is the need to understand UIC's role and actively develop frameworks suited to specific regions. Future research should focus on creating these frameworks, considering the unique challenges and conditions of different areas. This is essential for institutions to remain competitive globally and contribute to their local socio-economic environments.

In summary, this discussion pulls together important points from existing UIC research, highlights gaps, and sets a direction for future research and development. Addressing these gaps will help scholars and practitioners deepen their understanding of UIC, strengthen its theoretical bases, and develop effective frameworks that support economic and social growth across various global contexts.

7. Conclusion

UICs emerge as pivotal mechanisms for driving innovation and economic development. While the potential benefits are substantial, this study recognizes the multifaceted challenges and hindrances that can impede the success of such collaborations. Through a systematic literature review, the study endeavors to shed light on factors influencing UIC's success, offering recommendations derived from scholarly insights.

The study underscores the significance of geographical proximity, revealing that a closer distance between universities and industries correlates with higher knowledge exchange and innovation capacity. However, it is noted that the industry often shows greater interest in collaboration, emphasizing the need for strategic approaches to encourage reciprocal engagements. The functionalization of conceptual frameworks proves pivotal. Successful collaboration hinges on the effective operationalization of UIC frameworks, highlighting their instrumental role in shaping the performance and development of all involved actors and stakeholders. Results indicate a prevalent asymmetry, with industry demonstrating more interest in collaborating with universities than the reverse. This underscores the need for tailored strategies to enhance university engagement with industry partners. Policymakers are urged to foster an environment conducive to UICs, recognizing the regional specificity in crafting policies that facilitate collaboration. Incentivizing and supporting the development of tailored UIC frameworks can be instrumental in realizing economic and innovative potential.

Future research should delve into refining and empirically testing UIC frameworks, considering the geographical nuances and educational dynamics. Longitudinal studies can provide insights into the sustained impact of UICs and aid in continuous improvement. Industry and university practitioners are encouraged to embrace collaborative initiatives and leverage UIC frameworks strategically. The study emphasizes the need for reciprocal engagement and underscores the role of conceptual frameworks in optimizing collaboration outcomes.

In moving forward, it is imperative for stakeholders to collaboratively contribute to the development and implementation of effective UIC frameworks. Policymakers should craft region-specific policies, researchers should delve into refining existing frameworks, and practitioners should actively engage in reciprocal collaborations. By doing so, we can harness the full potential of UICs to drive innovation, economic development, and societal progress. This study lays the groundwork for a concerted effort to bridge the gap between academia and industry, offering a roadmap for fruitful collaborations that transcend barriers and unlock transformative possibilities for specific regions.

Compliance with ethical standards

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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