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Higher education institutions-led entrepreneurial ecosystem building: a systematic review from university-industry knowledge exchange perspective

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Abstract: This systematic literature review explores how universities contribute to Entrepreneurial Ecosystems (EEs) through Knowledge Exchange (KE) with industry. While universities provide critical resources and specialised knowledge that foster venture creation and growth, most prior studies have examined university-industry collaboration broadly rather than its interaction with EEs. To address this gap, 21 peer-reviewed English-language articles published between 2015 and 2025 were retrieved from Scopus and Web of Science and analysed using bibliometric and thematic methods. Articles unrelated to university-industry KE or outside the timeframe were excluded. The review found that universities engage in KE via consultancy, contract research, collaborative research, licensing, patents, Continuous Professional Development (CPD), research commercialisation and open innovation communities. These mechanisms promote the commercialisation of new technologies and ideas, strengthen EEs and foster spinoffs, high-technology startups and impact-driven entrepreneurship, underscoring the multifaceted nature of university-industry KE.

Keywords: HEIs; higher education institutions; entrepreneurial ecosystem building; knowledge exchange mechanisms; entrepreneurial university; university-industry knowledge exchange; contract research; continuous professional development; impact-driven entrepreneurship; collaborative research; systematic literature review.

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1 Introduction

In recent decades, Higher Education Institutions (HEIs) have evolved to become critical players in the development of Entrepreneurial Ecosystems (EEs) (Audretsch et al., 2024; Kapturkiewicz, 2022; Wang et al., 2023). EEs contribute to regional economic development by promoting innovation and sustainable growth and creating an environment where entrepreneurs can thrive (Isenberg, 2010; Stam, 2015; Spigel, 2017). Moore (1993) conceived the EEs notion to explain the interdependent relationships between a firm and its stakeholders. Later, Cohen (2006) defined an EE as a distinct combination of interdependent actors in a geographical territory that affects an integrated group of actors and the economy's construction and consequent trajectory. Mack and Mayer (2016) conceptualised an EE as a system with interacting components promoting startup development and regional entrepreneurial activities. More contemporary scholars have built on prior definitions to define an EE as a constellation of interlinked actors and factors, comprising enterprises, individuals, institutions and resources, which collectively augment and promote new business creation and growth in a specific geographical region or industry (Cavallo, 2019; Kuckertz, 2019). EEs, such as Silicon Valley in San Francisco, California and Tel Aviv, Israel, provide entrepreneurs with vital resources, including legal support, infrastructure and co-working spaces to start and grow businesses (Leal et al., 2023).

The multifaceted university-industry interactive dynamics have amplified collaboration and Knowledge Exchange (KE) between HEIs and industry (Miller et al., 2018). University-industry KE is broadly defined as a collaborative process through which academia and industry share knowledge, expertise and skills to foster innovation, resolve prevailing practical challenges and improve the socioeconomic outlook of society (Dang et al., 2024; Hughes and Kitson, 2012; Perkmann et al., 2013). Governments have growingly recognised and stimulated university-industry KE to create knowledge-based economies (Tseng et al., 2020; Zhao and Li-Ying, 2024). Under the Triple Helix model, which accentuates academia-industry-government collaboration (Galvao et al., 2019; Okonofua et al., 2020), universities invent new technologies and supply skilled and specialised labour to foster a knowledge-based economy (Audretsch, 2014; Thomas and Pugh, 2020).

Hewitt-Dundas (2012) stressed proper alignment between universities' priorities and organisational goals to improve interconnectedness and collaboration outcomes. In the last three decades, many universities globally have adopted the entrepreneurial university concept to contribute to regional sustainability (Cai and Ahmad, 2021). The entrepreneurial university, characterised by commercialisation and incubation, industry collaboration, innovation, research and development (R&D) and a strong culture (Klofsten et al., 2019; Baporikar, 2022), has rapidly taken centre stage in today's higher

education discourse and practice. HEIs combine their traditional teaching and research missions with the new entrepreneurial university notion to position themselves as crucial actors in mitigating environmental challenges and promoting socioeconomic development (Cai and Ahmad, 2021).

Universities have recently evolved to become key drivers of knowledge-based entrepreneurship, problem resolution and regional economic development (Audretsch, 2014; Thomas and Pugh, 2020). They use their extensive learning networks and broad-based coalitions with state and non-state actors to meet regional needs by combining resources (Jacobides et al., 2018). Universities' contribution to EEs has elicited substantial scholarly attention (Petruzzelli and Murgia, 2021; O'Dwyer et al., 2023; Skute et al., 2019). A growing body of literature indicates that HEIs serve EEs with entrepreneurship training programmes, counselling and mentorship for creating and testing innovative prototypes (Guerrero et al., 2016; Mueller, 2023; Wright et al., 2017). Universities also contribute to EEs through the integrated performance of cutting-edge research, knowledge networks and human capital development (Audretsch, 2014; Guerrero and Urbano, 2012; Ierapetritis, 2019). A systematic review of scholarly works in this subfield can yield valuable insights into the university's EE input, inform evidence-based decision-making, unearth gaps and inconsistencies and serve as groundwork for meta-analyses (Askie and Offringa, 2015).

Recent empirical studies (Audretsch et al., 2020; Bruneel et al., 2010; D'Este and Patel, 2007; Lam et al., 2020) have called for further exploration of the universities-EEs interplay to fill gaps in past systematic reviews. Though Ankrah and Al-Tabbaa's (2015) reviewed is widely cited and foundational in the university-industry collaboration framework, it exhibits fundamental weaknesses, mainly when analysed against contemporary standards for systematic reviews. First, the authors underreport the search strategy – they do not provide complete transparency regarding the specific search terms and justifications for the time span or inclusion/exclusion criteria. Second, the analysis is descriptive, with minimal evaluation of findings' relevance and contribution to the entrepreneurship field.

Third, the review is outdated in view of recent developments, potentially predating critical aspects like inclusive innovation and sustainability agendas (Nimfa et al., 2024; Sánchez-Hernández et al., 2019; Singh et al., 2024). On its part, Mascarenhas et al.'s (2018) reviewed adopted a narrow database search, solely relying on Web of Science (WoS), prospectively omitting relevant studies indexed in other databases such as Scopus, ProQuest and Google Scholar. While the scholars advocate a deeper exploration into how firms develop absorptive capacity through university-industry cooperation, their work falls short on actionable recommendations or frameworks that could guide university-industry policymakers and managers.

Like Mascarenhas et al. (2018) and Rossoni et al.'s (2024) reviewed relied exclusively on Scopus, overlooking relevant publications in other databases, such as WoS and ProQuest. Additionally, the review's research agenda lacks operational clarity, like decision frameworks for policymakers and university-industry managers. Finally, Passos et al. (2023) presented a review with limited methodological transparency. The absence of clear documentation on the inclusion and exclusion criteria and data extraction procedures casts significant aspersions on the replicability and rigour of their findings.

Against this backdrop, this study aims to address critical gaps in previous systematic reviews. First, to conduct a systematic review that is methodologically transparent, multi-sourced and analytically robust, to provide a more reliable and actionable understanding of university-industry collaboration and contributions to EE development. Second, to integrate recent developments in entrepreneurship, such as sustainability, to augment the study's relevance to current and emerging challenges. Ultimately, to contribute a more holistic and policy-relevant perspective to the university-industry collaboration literature. The rest of this paper is structured into three broad sections: research methodology, results and discussion and conclusion.

2 Research methodology

This study adopted a Systematic Literature Review (SLR) approach to address the underlying aim. Unlike traditional literature review methodologies, such as critical reviews, narrative reviews and conceptual reviews, SLRs are comprehensive and objective (Tranfield et al., 2003), reproducible and transparent (Briner and Denyer, 2012; Snyder, 2019) and suitable for evidence-based decision-making (Boell and Cecez-Kecmanovic, 2015). Specifically, this study employed the structured SLR protocol advanced by Tranfield et al. (2003), which accentuates the replicability, openness and integration of empirical evidence to address a specified research question, enhancing objectivity and rigour (Ankrah and Al-Tabbaa, 2015; Moher et al., 2009; Rybnicek and Königsgruber, 2019). The three steps outlined in Tranfield et al.'s (2003) framework (planning, conducting and reporting and disseminating the results) were followed to complete the review.

2.1 Step 1: Planning the review

The planning phase includes identifying the need for the study, preparing a proposal for review, and creating a review protocol (Tranfield et al., 2003). In this study, the two reviewers, who doubled as authors, met regularly and clarified controversial constructs and agreed on the inclusion and exclusion of studies. The reviewers also developed a protocol to guide the review, focusing on the research questions, the focus of the study, the search strategy for identifying relevant sources and the inclusion and exclusion criteria. To better understand and develop a comprehensive understanding of university-industry KE mechanisms and their importance to EEs, this study sought to answer the following Research Questions (RQs):

- *RQ1*: What are key mechanisms that facilitate KE between universities and industry?
- *RQ2*: What role does university–industry KE play in fostering EE outcomes?

Relevant articles were searched in Scopus and Web of Science (WoS) databases, potentially limiting access to a wide range of publications. However, these databases were chosen because they feature an expanded spectrum of journals, support faster citation analysis and feature high-quality peer-reviewed journals (Falagas et al., 2008; Rybnicek and Königsgruber, 2019). The search process used the following keywords: university-industry AND knowledge AND exchange OR collaboration AND

entrepreneurial AND ecosystem to locate published peer-reviewed articles in the two databases. The search process was not restricted to the articles' country of origin or sector/industry. The time interval for article publication was limited to between 2015 and 2025.

The time interval from 2015 to 2025 was consciously selected to capture the most recent and methodologically advanced contributions to the university–industry collaboration discourse (Passos et al., 2023; Tolin and Piccaluga, 2024). The selected timeframe reflects a period marked by significant developments in collaboration theory and practice, including the growing emphasis on open innovation, digital transformation and sustainability agendas, all of which have reshaped the university–industry partnerships (Evans et al., 2023; Oyedele and Oyero, 2022; Shenkoya and Kim, 2023; Yun, 2023). Moreover, post-2015 scholarship has increasingly responded to global shifts, such as the United Nations' Sustainable Development Goals (SDGs) and the COVID-19 pandemic's aftermath, contexts that earlier studies may have overlooked (Filho et al., 2023; Shuai et al., 2022). By restricting its scope to the past decade, this paper avoids redundancy with earlier syntheses while ensuring the inclusion of high-quality research that better reflects the current and future directions of university–industry collaboration.

The inclusion criteria included: (1) articles exploring the mechanism for fostering KE between universities and industry or the effect of university-industry KE on EE (2) published between January 2015 and April 2025 (3) peer-reviewed journal articles (4) published in English. The exclusion criteria entailed articles not focusing on the mechanism for fostering KE between universities and industry or the effect of university-industry KE on EE (2) not published between 2015 and 2025, (3) non-peer reviewed or other document types (i.e., books/chapters, reports, theses and conference papers) and (4) authored in different languages rather than English.

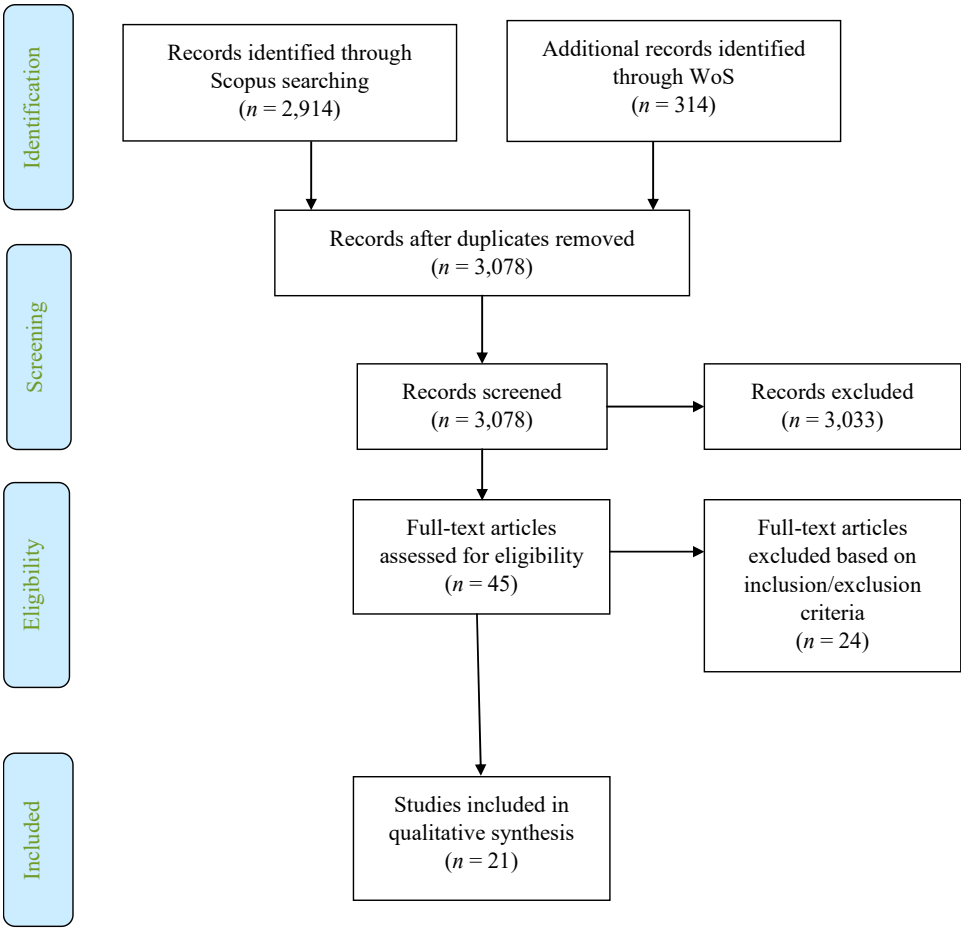
2.2 Step 2: Conducting the review

The identified keywords were used to search articles in Scopus and WoS in separate intervals. The initial search yielded 3228 items (Scopus=2914; WoS=314). Duplicates (n=150) were eliminated, resulting in 3078 entering the screening stage. The remaining articles were filtered based on abstract, topic and title, subsequently eliminating 3033 documents. The 45 remaining documents were read fully, and 24 of them were removed based on the inclusion and exclusion criteria. Hence, 21 articles were included in the final qualitative analysis. Figure 1 presents a summary of the article selection process.

2.3 Step 3: Report and dissemination

The final phase entailed a descriptive review of the articles to uncover emerging themes and categories. The articles were thoroughly reviewed and the extracted information analysed via thematic analysis.

Figure 1 Article selection process (see online version for colours)



3 Results and discussion

3.1 Bibliometric analysis

A bibliometric analysis was undertaken to develop a better understanding of the articles' key parameters. This analysis focused on three key categories: publication year, publication journal and country of origin.

- *Publication year*: Based on the analysis, scholarly attention on university-industry KE is concentrated in the last four years (2020–2024) (see Figure 2). This distribution demonstrates a reactive research trend, possibly driven by contemporary innovative policies and agenda.
- *Country of origin*: The articles' country of origin was distributed as follows: UK (4), Germany (4), China (3), Saudi Arabia (3), India (2), USA (2), Colombia (1), Italy (1)

and Canada (1). This distribution illustrates a comparatively limited coverage of countries from Africa, the Middle East and Latin America, implying a prospective Western and Global North bias in literature, sparking concerns about the generalisability of findings.

- *Publication journal*: Except Technovation, which featured two articles, all other journals were represented by a single contribution each, highlighting a fragmented publication landscape and a lack of concentrated scholarly discourse on university–industry KE within specific academic journals (see Table 1). A possible explanation for this dispersion could be the interdisciplinary nature of university-industry KE, which revolves around multiple fields, including entrepreneurship, innovation and technology, making it less possible for research to coalesce within a single or a few journals.

Figure 2 Articles' years of publication (see online version for colours)

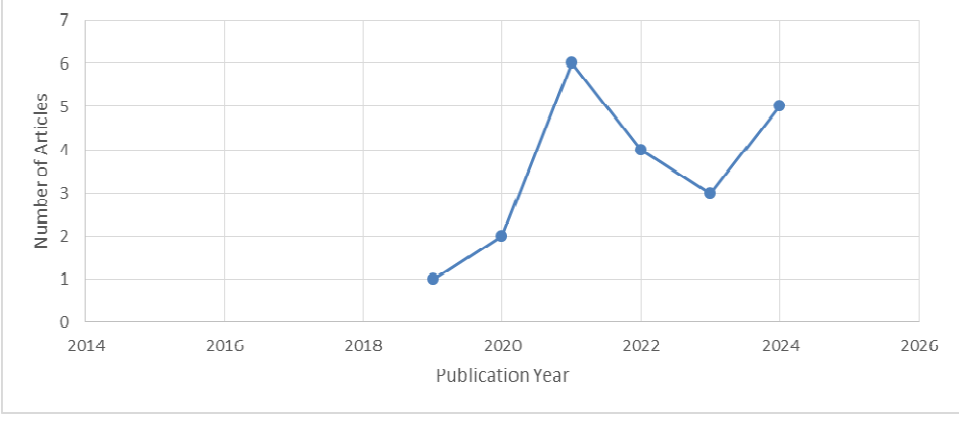


Table 1 Publication journals

Journal	*Number of articles*
The Journal of Technology Transfer	1
Triple Helix	1
Regional Studies	1
Industry and Innovation	1
Eurasian Business Review	1
The Journal of Technology Transfer	1
Journal of Entrepreneurship and Innovation in Emerging Economies	1
Technological Forecasting and Social Change	1
International Journal of Technology, Knowledge and Society	1
European Journal of Higher Education,	1
Management Decision	1
The Journal of Technology Transfer.	1
Research Policy	1

Table 1 Publication journals (continued)

Journal	*Number of articles*
Technovation	2
Asian Journal of Technology Innovation,	1
The Journal of Technology Transfer	1
Journal of Open Innovation	1
Publications (Basel)	1
Journal of Cleaner Productions	1
Journal of Information Studies and Technology (JIS&T)	1

3.2 Qualitative results and analysis

A thematic analysis of the reviewed 21 articles yielded two broad themes: university-industry KE mechanisms and university-industry KE's contribution to EE, with each related to several sub-themes. Sub-sections 3.2.1 and 3.2.2 synthesise and critically discuss these themes and related sub-themes.

- *University-industry KE mechanisms*: A review of the articles disclosed that university-industry KE occurs through eight distinctive mechanisms: consultancy, contract research, continuous professional development (CPD), collaborative research, licensing, patents, open innovation communities and research commercialisation.
- *Consultancy*: One strand of studies shows that universities engage in KE with industry through consultancy to leverage their knowledge assets and increase formal commercialisation outcomes. Pickernell et al. (2019) reported that UK universities valorise their knowledge assets to industry, especially SMEs, through consultancy to capitalise on their knowledge asset for economic purposes. Similarly, Zhou and Baines (2024) established that universities use consultancy as an informal KE activity that amplifies formal commercialisation outcomes such as patenting and licensing income, supporting earlier research by Crespi et al. (2011). While both Pickernell et al. (2019) and Zhou and Baines (2024) identified consultancy as a key channel for university-industry KE, their analyses overlook emergent forms of exchange that fall outside the traditional academic structures, notably conference conversations and personal networks that can also promote collaboration between the two stakeholder clusters.
- *CPD*: This review identifies CPD as a vital informal KE mechanism for universities to leverage their knowledge capital for income generation. Zhou and Baines (2012) established that HEIs use CPD activities, mainly courses for businesses and the community, to develop industry relationships, leading to innovations and technology-enabling patents. In resonance, Pickernell et al. (2019) reported that universities use CPD to generate profit from inventions by sharing knowledge with industry. Johnston et al. (2024) found that universities use CPD for KE to generate income. However, a significant portion of revenue from this KE activity was attributed to high-technology research projects. Though the three studies reinforce each other on this commercially oriented narrative, they potentially overlook the

broader non-commercial implications of CPD, like capacity building and long-lasting relational trust (Friedman, 2023). Therefore, while CPD is recognised for its commercial significance in university-industry KE, its role in promoting sustainable partnerships requires further exploration.

- *Open innovation communities*: Open innovation communities are visibly one of the under-explored mechanisms for fostering university-industry KE. Open innovation spaces, defined as spaces that allow for the exchange and exploitation of knowledge, collective learning and opportunities to invent (Lave, 1991), enhance collaboration between HEIs and industry through knowledge sharing and collective problem-solving. Vélez-Rolón et al. (2020) demonstrated that these communities influence how students, trainers and participants share knowledge with industry players. For example, computer tools provide a platform for creating and sharing knowledge. Despite this potential, it is surprising that open innovation communities' link with KE is only confirmed by a single study. This limited evidence base raises concerns about the generalisability of the findings and illustrates a need for a broader empirical validation across institutional and cultural landscapes.

Open innovation communities may have limited empirical engagement in the university–industry KE literature due to various reasons. Firstly, their flexible and non-centralised nature makes them challenging to conceptualise, quantify and evaluate across diverse settings. Contrary to formal KE mechanisms, such as licensing and consultancy, open innovation communities primarily operate informally, spanning institutional boundaries, including diverse actors and generating outputs that may not be captured through traditional performance measures (Dave and Sajja, 2025). This complexity may discourage empirical research or lead to the marginalisation of open communities in KE research undertakings that favour quantifiable outcomes. Secondly, the interdisciplinary and emergent nature of open innovation communities implies they are often studied under varied conceptual umbrellas, notably digital innovation, co-creation and living labs, resulting in fragmentation within extant literature. This lack of conceptual consistency makes it challenging to accumulate robust evidence and conduct comparative studies that situate open innovation communities clearly within the KE framework. Given this challenge, scholars should work toward defining and categorising different types of open communities, distinguishing between digital platforms, physical spaces and hybrid frameworks, forming a solid foundation for systematic research.

- *Contract research*: Contract research was reported as a core informal mechanism through which universities engage in KE with industry to generate income. Pickernell et al. (2019) noted that universities transfer knowledge to industry through contract research, which encompasses formal agreements whereby business entities contract HEIs to conduct research on their behalf for a fee. Specifically, they found that UK universities complete strategic research projects commissioned by SMEs. The studies by Johnston et al. (2024) and Rossi and Sengupta (2022) also revealed that contract research initiatives allow industry players to tap into HEIs' innovative research undertakings to supplement their income bases. Collectively, these findings position contract research as a vital resource that enables universities and industry to generate additional income and access state-of-the-art innovations, respectively. Nonetheless, the studies downplay the possible adverse effect of the industry's control over academic autonomy in contract research arrangements.

Though informal KE channels such as CPD and contract research are increasingly acknowledged for their commercial significance, several weaknesses warrant critical attention. A notable concern is the inconsistent formalisation and documentation of informal engagements, which can result in undervaluation of their contributions within institutional performance metrics. Additionally, such activities often rely on personal relationships and individual academic networks (Abdulai et al., 2022), which may hamper inclusivity and scalability across broader university structures. Informal KE channels may also predispose HEIs to imbalanced power dynamics, where industry influence can tilt university priorities, chiefly in the context of contract research. Regardless of these limitations, informal KE mechanisms yield significant non-commercial benefits, including community engagement, capacity building, mutual trust and long-term collaboration (Marsh et al., 2008; Martinez et al., 2022). Although challenging to measure, these intangible outcomes contribute to social innovation, inclusive knowledge dissemination and stronger place-based partnerships that align with broader societal missions of higher education institutions (Abdulai et al., 2022; Martinez et al., 2022). Hence, while the commercial outcomes of informal KE are widely acknowledged, their non-commercial value merits greater empirical attention and strategic emphasis.

- *Collaborative research*: This paper finds that collaborative research fosters university-industry KE through multiple mechanisms, including trust building, self-image, startup growth and mutual benefits. Collaborative research implies a partnership in which universities and industry work together to design, fund and deliver research projects (Ankrah and Al-Tabbaa, 2015). Zhou and Baines (2024) established that collaborative research allows the universities and industry to build trust and strong relationships, opening up a possible avenue for the commercialisation of new knowledge and technology. Almuqrin (2022) reported a significant and positive relationship between self-image and knowledge sharing between Saudi universities and industry through collaborative research. Henry and Lahikainen (2024) noted that collaborative projects drive European entrepreneurial ecosystems by facilitating startup growth. Pickernell et al. (2019) discovered that universities collaborate with SMEs to undertake research projects for mutual benefits, resulting in knowledge spillover for both entities. While Nazneen et al. (2023) reinforced the role of collaborative research in fostering university-industry KE, they indicate that it has a partial mediating influence. The five cited studies portray collaborative research as a key medium through which universities share knowledge with industry practitioners. However, the studies overlook the possible mediating influence of conflicting objectives and timelines between the two actors on the depth and openness of KE. Hence, a fuller understanding of the role of collaborative research in fostering KE between industry and universities requires additional examination of the mediating influence of timelines and divergent goals.

- *Licensing*: The results demonstrate that different university typologies exploit research output licensing to engage in KE with industry in varying degrees. Pickernell et al. (2019) emphasised that universities use licensing to share knowledge with industry, albeit to a lesser extent than soft channels like consultancy. Zhou and Baines (2024) noted that mid-sized universities utilise licensing to share knowledge with industry than larger, high-intensive universities. This finding suggests that though licensing remains a formal channel for KE between university

and industry, its relative use depends on university size and strategy. For example, mid-sized universities may rely exclusively on licensing for KE due to their limited capacity to engage in informal mechanisms like consultancy. This approach raises questions about the effectiveness and inclusivity of licensing as a key KE tool across diverse university contexts. These reservations notwithstanding, the use of licensing to transfer intellectual property, technology and research outcomes is symbiotic – it allows HEIs to generate revenue and impact communities and amplifies innovation commercialisation among industries.

- *Patents*: Based on four articles, this SLR establishes that universities use patents as a crucial mechanism for sharing knowledge with industry to foster economic development, structured use of knowledge and income generation. Patents imply intellectual property rights offered to universities to exclude others from using or selling their innovations (Geuna and Rossi, 2011). For instance, Chinese universities have recently transferred a significant output of patents to industry, with their scales correlating with economic development, albeit more in developed regions than in less developed ones (Yang et al., 2024). Abdulfasi (2024) reported a gradual rise in the volume of patent registrations among Saudi HEIs, with King Faisal University (KFU) leading, followed by King Fahd University of Petroleum and Minerals (KFUPM), King Abdullah University of Science and Technology (KAUST) and King Abdulaziz University (KAU). Wang and Lu (2021) confirmed that patents facilitate structured knowledge transfer from universities to industry. Johnston et al. (2024) illustrated that patents enable universities to generate income by protecting their intellectual property rights in their engagement with industry. However, emphasis on this KE mechanism may privilege well-resourced universities with strong legal and administrative infrastructure, potentially reinforcing existential inequalities in research output and access to innovation.

- *Research commercialisation*: KE between universities and industry also occurs via research commercialisation, which involves transforming academic research outputs like knowledge into marketable products that generate economic value (Pickernell et al., 2019). Piqué et al. (2021) noted that universities exchange knowledge with industry through science and technology commercialisation. This process enables students to attract investors who are ready to fund innovative ideas for entrepreneurial startups. Battaglia et al. (2021) demonstrated that universities use research commercialisation to share knowledge with industry, with relational enablers (such as trust and communication) mediating the relationship. Although these two studies underscore the role of research commercialisation as pivotal to university-industry KE, they do not explore institutional disparities based on resource availability. A cross-comparison of universities of varying resource capacities can yield nuanced insights into the significance of commercialisation in HEIs-industry KE.

- *University-industry KE's contribution to EE*: As shown in Table 2, eight of the 21 reviewed articles demonstrate that university-industry KE leads to spinoffs, high-technology startups and impact-driven entrepreneurship.

Table 2 University-industry KE contribution to EEs

University-Industry KE Contribution to EEs	*Publication*
Spinoffs	(Zhou and Baines, 2023; Piqué et al., 2021)
High-technology startups	(Breznitz and Zhang, 2022; Cunningham and Menter, 2021; Vardhan and Mahato, 2021; Das and Pattnaik, 2023)
Impact-driven entrepreneurship	(Etzkowitz and Zhou, 2021; Lehmann et al., 2022, 2024)

- *Spinoffs*: Consistent with Piqué et al. (2021) and Zhou and Baines (2024) found a positive relationship between collaborative research and the establishment of spinoffs, which entails forming a firm from an existing enterprise by leveraging intellectual property (Bager et al., 2010). The scholars establish that collaborative research allows research teams to develop novel ideas and technologies, including valuable social capital necessary for spinoffs. However, Zhou and Baines (2024) noted that other informal KE activities (i.e., CPD, consultancy and contract research) have an insignificant effect on spinoff creation. This distinction underscores the limitations of more informal KE mechanisms in generating high-impact innovation outcomes, while collaborative research appears effective in building the social and technological infrastructure required for spinoff success due to its emphasis on long-term partnerships between university and industry. However, the narrow focus on spinoffs as the primary outcome can be problematic in the context of sustainable development, which requires broader societal, environmental and ethical considerations. While informal KE mechanisms like consultancy are less likely to yield immediate commercial returns, they can foster community engagement and dissemination of socially relevant knowledge, creating a platform for long-term sustainable innovation. Hence, a more balanced KE framework incorporating formal and informal mechanisms is vital to spur sustainable development within specific entrepreneurial ecosystems.
- *High-technology startups*: Breznitz and Zhang (2022) shown that university-industry KE promotes high-technology startups. Similarly, Cunningham and Menter (2021) found a positive contribution of entrepreneurial-oriented universities to the third mission (producing knowledge to benefit the economy, society and culture (Etzkowitz, 2011), especially high-technology startups in funded regions. Cunningham and Menter (2021) stressed that university-industry collaboration significantly impacts high-technology entrepreneurship. Their study found that larger universities and areas with higher population density and innovativeness have elevated levels of high-technology entrepreneurship. Vardhan and Mahato, (2021) and Das and Pattnaik (2023) shown that university-industry KE support high-technology startup development through access to incubators (nurturing and helping early-stage companies, providing resources and mentoring entrepreneurs (Bruneel et al., 2012). However, this focus on resource-based support may overlook other critical factors like government policy, culture and relational dynamics required to support early-stage enterprises, ensuring sustainable development within EEs.
- *Impact-driven entrepreneurship*: Collaboration between universities and stakeholders, including local communities, businesses and government entities,

fosters a supportive ecosystem for impact-driven entrepreneurship (Lehmann et al., 2024). Earlier research by Lehmann et al. (2022) further shown that university-industry collaboration positively affects firms' financial performance. Etzkowitz and Zhou (2021) established that universities integrate research and education to create structures for entrepreneurship at the industry level. While these studies highlight the contribution of university-industry collaboration to entrepreneurship, they underemphasise the possible tensions between profit-oriented entrepreneurial goals and broader environmental responsibilities. University-industry partnerships risk perpetuating short-term entrepreneurship goals if not explicitly aligned with sustainable development priorities. Therefore, a critical re-orientation ensures that universities are not only economic catalysts, but also sustainable anchors that embed Sustainable Development Goals (SDGs) within the EE. This approach can help transform the focus from solely economic metrics to a more holistic impact model.

4 Conclusions, implications, limitations and recommendations for future research

4.1 Conclusions

This SLR shows that universities engage in KE with industry through consultancy, contract research, CPD, collaborative research, licensing, patents, open innovation communities and research commercialisation. KE between the two EE actors also lead to spinoffs, high-technology startups and impact-driven entrepreneurship. These findings suggest the multifaceted nature of university-industry KE mechanisms and their potential to spark spinoff development, high-technology startups and impact-driven entrepreneurship.

4.2 Practical implications

This review contributes to practice by highlighting fundamental considerations for university and industry practitioners. Rather than focusing on formal or informal KE mechanisms, universities and industry need to strike a balance between the two categories to foster a more sustainable engagement and vibrant EE. The paper establishes that university-industry collaboration results in high-technology startups and impact-driven entrepreneurship. Universities and industry can leverage this outcome to contribute to thriving startups within their EEs by establishing strong collaborative research arrangements. For instance, the Fraunhofer Society, a publicly-owned research organisation in Germany, partners with industry players by linking scientists to SMEs in its technology transfer programme, significantly enhancing firms' long-term absorptive capacity and inter-organisational trust (Hilkenmeier et al., 2021).

Since 1975, the Massachusetts Institute of Technology (MIT)'s Industrial Liaison Program (ILP) has maintained long-term partnerships with multiple global corporations, including Boeing and Microsoft, leading to more than 200 high-technology spinoffs and enhancing academic research alignment with market peculiarities and significant economic contribution to the Boston EE (De Wolff, 2024). Partnerships between Finland's Häme University of Applied Sciences and industry have also contributed to innovative product designs and rapid co-creation through university-industry projects by

helping students and company representatives collaboratively prototype and validate market-ready innovations (Ahonen et al., 2020). Collectively, these case studies demonstrate that active, trust-based and well-resourced university-industry collaborations anchored in structured frameworks can accelerate startup creation and strengthen EEs by embedding academic research within real-world industry settings.

4.3 Theoretical implications

A fundamental theoretical contribution of this paper is its depiction of university-industry KE as a non-singular, multifaceted system comprising formal (e.g., licensing, patents) and informal (e.g., CPD, consultancy) mechanisms. This finding supports and reinforces the Triple Helix model by illustrating that diverse KE pathways interact to promote EE outcomes such as spinoffs and impact-driven ventures. Hence, future refinements of the model should move beyond linear perspectives of KE and adopt more encompassing theoretical postulations that consider the multi-actor nature of EEs.

4.4 Limitations and recommendations for future research

Despite its novel insights, this SLR is not devoid of limitations. First, the study only reviewed 21 articles out of a total of 3228 located from the initial search of the two databases. A majority of the articles were eliminated because they did not meet the established inclusion criteria. However, the relatively small sample in this review raises concerns about its representativeness. This sample may also fail to capture the full diversity of perspectives, practices and regional variations in university-industry collaboration. As a result, the findings could be biased or lack generalisability, particularly in underrepresented regions or disciplines. Second, focusing heavily on bibliometric and thematic analyses may limit deeper insights into the contextual or qualitative dimensions of collaboration. Third, most of the reviewed articles were quantitative, lacking comprehensive qualitative insights.

Future research should employ qualitative approaches and case study designs to gain a more profound, context-rich understanding of the dynamics, challenges and enablers of university-industry KE. Case studies provide an effective method to explore the institutional, cultural, and relational complexities of KE mechanisms within specific EEs, allowing researchers to examine real-life interactions, strategies and implications in situ (Annamalah, 2024). Comparative analyses across universities of varying sizes, research capabilities and geographical contexts can also yield meaningful insights into how institutional scale and structure drive KE strategies and their subsequent impacts. Such comparisons are necessary to unearth best practices, challenges and context-related outcomes, particularly between research-intensive HEIs and smaller, teaching-focused institutions.

Longitudinal studies can also track the evolution of KE mechanisms and outcomes over time. Undertaking longitudinal investigations can help uncover the long-term effects and sustainability of university-industry collaboration, appraising how trust, networks and innovation capabilities develop or erode across different stages of engagement. To further enrich the analysis, researchers should adopt mixed-methods approaches that incorporate quantitative indicators (e.g., spinoffs, patents, licensing revenue) with qualitative insights (e.g., stakeholder perceptions, institutional narratives) to produce holistic and robust evidence on the complexities of KE.

Moreover, there is a pressing need for future research to extend the geographical scope of KE inquiry to include understudied regions, particularly Africa, the Middle East and Latin America. These contexts provide fertile ground for understanding how KE unfolds in settings with different levels of institutional maturity, policy support and resource availability. Investigating KE in such geographical contexts will broaden the empirical base and help develop more inclusive and context-sensitive theories of university-industry engagement.

Declarations

All authors declare that they have no conflicts of interest.

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